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Public Roads

A JOURNAL OF HIGHWAY RESEARCH

Constantly increasing traffic is overloading inadequately designed highways

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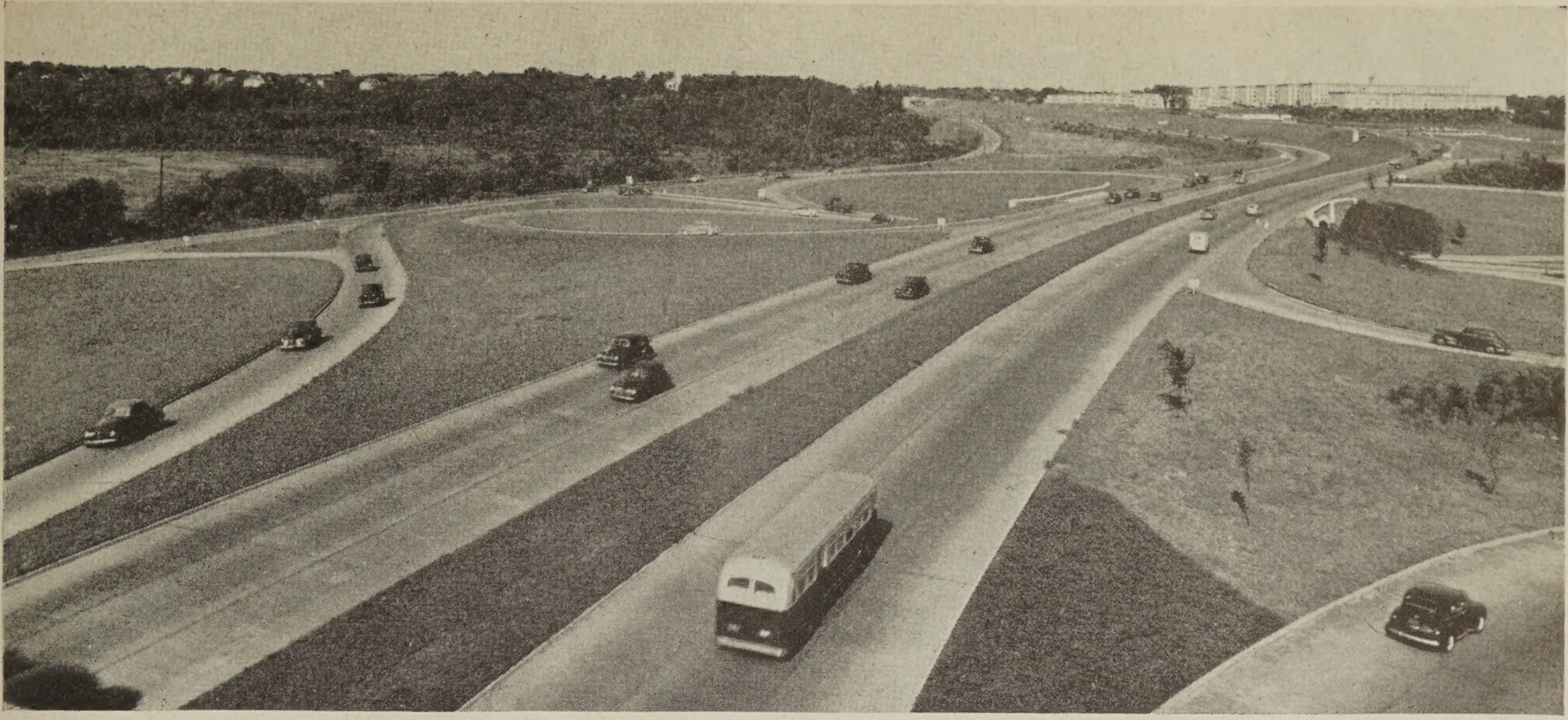
FEDERAL WORKS AGENCY

E. A. STROMBERG, Editor



The Pentagon system, with 67 million vehicle-miles of travel a year, has an almost perfect safety record.

By THOS. H. MacDONALD,
Commissioner of Public Roads

HIGHWAY SAFETY

Driver Behavior—Key to Safe Highway Design

The Society of Automotive Engineers' Second David Beecroft Memorial Lecture

In our knowledge of the manner in which highways are used by the mass of traffic, we have reached the point at which we can coordinate driver behavior under prevailing traffic conditions with the geometric details of highway design. The degree to which the criteria so determined are accepted and intelligently applied in practice will determine the degree of safe efficiency of our future highways.

Our principally used street and highway systems are largely the product of the past third of a century. Most of the improved mileage has been built under public pressures, and also by legislative edict, to stretch the dollars over maximum lengths. In general, the design tolerances have been too meager for today's quantity and characteristics of traffic. Traffic-overloaded highways are one of the chief underlying causes of highway accidents.

Geometric highway design to induce proper driver behavior in traffic streams will require rebuilding or rehabilitation of the major mileage of both the primary and principal secondary routes to more liberal standards. The cost will exceed annual expenditures heretofore reached, and will require a long period—a minimum of 15 years and probably longer. Carefully planned annual programs of rehabilitation are an emergency need.

The appealing angle of highways designed for safe operation is that safe designs cost no more than unsafe designs, if total costs are considered. The initial cost of constructing a highway is only one element, and far less costly than other elements, of the total annual cost of highway transport. The costs of owning, maintaining, and operating more than 40 million motor vehicles are many times the expenditure for highway construction and maintenance. When these total costs to road users are considered, plus the value of lost time for the millions of passenger cars used for business and for all vehicles operated by paid drivers, and the value of saving in time on the investment of farmers, merchants, and industrialists in their vehicles and in the merchandise carried, there are few highways indeed for which the small additional investment to design for safer operation cannot be justified on the economic basis of returns to road users. When there are added to these costs the cost of highway accidents that can be prevented by highways designed for safety, the economy of such highways is unassailable. Incidentally, highway engineers have too long wrecked professional conviction against the stone wall of comparative "per mile" costs. We need a new concept that recognizes the actual passenger-mile and ton-mile services returned as the realistic measure of highway construction costs.

Highways designed for safety on the national scale will be realized all too slowly. There are many accidents which highways designed within cost possibilities cannot prevent. The only hope of maintaining the downward trend of accidents, particularly fatal accidents, is the vigorous application, enforcement, and popular support of the Action Program of the President's Highway Safety Conference.

This well-planned highway easily and safely carries 10,000 vehicles a day at reasonable speeds.

THROUGH the many years of his activities in the rapidly expanding fields of automotive engineering and motor vehicle utilization, David Beecroft was a positive force for technical progress. He constantly brought to his associates the impression of a restless inner drive to secure action, and an eagerness, merging into impatience, to defeat delays in moving toward higher standards of excellence for the many diverse components that must be integrated and perfected to provide the desired end product—efficient highway transport. He insisted that the attack on each problem accord with sound techniques, and believed that advance comes through research. In 1921, when president of the Society of Automotive Engineers, he said: "The roots of the present are always found in the past, and we must study the past if we are to proceed correctly in interpreting sanely the days that are to come."

We might, perhaps, modestly record the progress that has been made in highway transport development since Mr. Beecroft gave expression to this principle. After four decades of accelerated growth in the extent and varieties of services provided by the motor vehicle, it is self-evident that in this period no other single factor has so profoundly affected the pattern of social and economic life in these United States. A particularly impressive chapter of the record would disclose the realized strength that highway transport provided the United States for both defense and offense during World War II.

It is more consistent with Mr. Beecroft's philosophy, however, to use the experience of the past to insure the complete rejection of the fatalistic suspicion that the current inefficiencies and hazards of highway transport are necessarily inherent.

If we are to gain mastery over highway transport as an efficient tool for national progress, and stop the toll that we are paying for its use in the tragic loss of life, the permanent injuries, and the financial costs of accidents that no nation, however wealthy, can afford, we must critically re-examine our policies and practices, particularly the thinking back of these, to find the causes that are responsible for our failures. We know we have taken many wrong turnings. Changing conditions require new horizons in our applied techniques as knowledge is unfolded and experience is more precisely interpreted. It is profitless to speculate upon what we might have done had we foreseen, in the early years, a reasonable fraction of the dimensions to which highway transport was so rapidly to grow, or had we anticipated more realistically its characteristics in actual operation.

It is a high honor to follow, in this series of papers,[1] Mr. Paul G. Hoffman, who in 1947 presented the first David Beecroft memorial lecture. There is, in the general confidence of his fitness to carry the world-wide responsibility as head of the Economic Cooperation Administration, a recognition of his major contribution and efforts to bring highway safety into effective unity with our everyday living.

In the ECA program the United States has accepted high international responsibility in the struggle to achieve democracy, which essentially means cooperation and coordination. The principle must be accepted and applied to every major feature of our national life if we are to be an example of our ideology worthy of the emulation of other nations. Highway transport consists of so many elements that we can only secure an excellent standard of service as we approach complete cooperation and coordination. On this premise, it appears to be responsive to the purpose behind the series of papers set in motion by Mr. Beecroft, to explore the present state of the art in the single field of highway design in relation to highway safety.

In this particular and limited field there is urgent need for a major shift in the approach to the determination of the geometric design. Since major changes in our thinking and in our policies applied in this field are indicated by the findings of intensive research now available, it may, by inference, be expected that need for major changes exists in other elements of highway transport. It is hoped that future papers in this series may present the record of the present, and also new concepts in the allied fields of motor-vehicle design, motor-vehicle administration, particularly driver licensing and driver training, traffic laws, enforcement, and safety education designed to fortify driver behavior with disciplined attitudes of mind. These are all interrelated and interdependent, and our mastery of the whole problem of street and highway transport with safety depends upon mastery in each of these fields.

This paper purports only to record the devoted work of many individuals and many organizations to advance the cause of highway safety. The Action Program of the President's Highway Safety Conference, the extensive work of the Automotive Safety Foundation, that of the National Safety Council, and of many others, are reflected in the conclusions reached. The factual data are the product of the Department of Research of the Public Roads Administration under Deputy Commissioner H. S. Fairbank, and in particular result from detailed research of O. K. Normann, Carl Saal, C. W. Prisk, W. P. Walker, A. Taragin, and others who have engaged in the field of traffic research intensively and devotedly over many years.

The application of such data to design practices of Public Roads is the product of the Department of Design under Deputy Commissioner H. E. Hilts and his associates. There is particular response to the advance in design requirements by the Urban Division under Joseph Barnett.

The effort has been made to eliminate personal opinion, and to substitute conclusions supported by detailed observations of controlled research carried on over a sufficient period and with adequate repetition to justify confidence in the results. It is, however, not the intention to reflect an implication of finality. Continuing research will refine and illumine problems which are as yet obscure, but it is certain that driver behavior en masse is the key to safe highway design.

THE BACKGROUND OF HIGHWAY DESIGN

For too long, and in too great degree, highway design has been distorted by the tyranny of wrong concepts. Most important of these in its adverse impacts is the error of thinking of the motor vehicle as static in relation to the highway. In use, the vehicle is dynamic and takes on very different qualities.

When the motor vehicle first appeared, it was held to be a legal interloper on highways whose function was to serve horse-drawn traffic. As the number increased, only minor concessions were made to its higher speed, in the way of superelevated curves—probably borrowed from prior railroad practice. The effects of railway engineering tenets upon highway design are evidenced by the meager tolerances which have been built into our roads, reflecting operations on fixed tracks not subject to deviation from course. The motor vehicle in motion is highly flexible; but at relatively low densities of traffic the operation begins to take on the character of stream flow, and the individual vehicle loses its identity and its freedom. As an integral part of a traffic stream, each vehicle affects, and is affected by, all of the other vehicles in its own flow line and in contiguous streams.

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[1] This paper was presented as the second David Beecroft memorial lecture at a meeting of the Society of Automotive Engineers in Washington, D. C., November 16, 1948.

The old adage—the proper study of mankind is man—is not only scientifically correct, but is the only approach to the problem of highway design with maximum safety. Human behavior at the wheel, with foot on the accelerator rather than the brake, is the all-important criterion for highway design. The implication here is not an invitation to speed, or to design with the objective of high speeds. Driver behavior en masse reflects normally average rural speeds of 42 to 48 miles per hour when reasonable freedom is permitted. As cars are designed, the foot on the accelerator is the normal driving position, and through the accelerator the driver expresses not only his desire to reach an objective, but in addition a wide range of reactions that may be conscious emotions or unconscious reflexes. The driver en masse is not designed for high speeds with safety. Once the mean and range of human behavior are determined by precise measurements extended to thousands of observations until the general pattern emerges, the design limits thus fixed will have sufficient tolerance to provide for the usual departures from the norm. Highway capacity adjusted to traffic volume is a major factor in safe highway design. True economy is served only if this test is met, and thus safety becomes directly a measure of efficient as well as economical design.

The ratio of commercial vehicles to passenger cars has important effects upon the road capacity to carry traffic. In 1904 the ratio of trucks and busses to passenger cars was 1 to 78; by 1910 this ratio had become 1 to 45; in 1920, 1 to 7.3; in 1930, 1 to 6.5; in 1940, 1 to 5.9; and it is expected that for 1948 the ratio will be about 1 to 4.5 (see table 1). The percentage of commercial vehicles in the total daily traffic flow is continuing to increase, and for this reason more adequate recognition of the requirements of such traffic must be incorporated in the design to insure safe, efficient operation of all traffic.

The influence of increasing the percentage of commercial vehicles upon the total capacity of multilane highways, under the favorable conditions of uninterrupted flow, is illustrated in table 2. On two-lane highways this influence on capacity is more severe.

Table 1.—*Registrations of automobiles and of trucks and busses*

Year	Registrations			Ratio of trucks and busses to automobiles
	Automobiles	Trucks and busses	Total	
1904	54, 590	700	55, 290	1 to 78. 0
1910	458, 377	10, 123	468, 500	1 to 45. 3
1920	8, 131, 522	1, 107, 639	9, 239, 161	1 to 7. 3
1930	22, 972, 745	3, 559, 254	26, 531, 999	1 to 6. 5
1940	27, 372, 397	4, 663, 027	32, 035, 424	1 to 5. 9
1947	30, 718, 852	6, 641, 611	37, 360, 463	1 to 4. 6
1948[1]	33, 225, 000	7, 332, 000	40, 557, 000	1 to 4. 5

[1] Estimated.

In the years just prior to 1946 the national fatality rate was about 12.0 deaths per 100 million vehicle-miles of travel. In January 1946, the rate was 12.4. The President's Highway Safety Conference was called in May 1946, and, notwithstanding the bad record of the first 3 months of that year, the upward trend was halted and turned abruptly downward so effectively that the year ended with a rate of 9.8. The wholehearted support, and the devoted interest and efforts of organizations, officials, and the public in putting into effect the Action Program developed through the Conference, are mainly responsible for the reduction in the fatality record to the estimated rate for 1948 of 7.8 per 100 million vehicle-miles. As this rate is lowered we must expect to reach a critical point at which a continuing decrease will prove impossible through education, enforcement, and the other means which have been responsible for the splendid record made since May 1946.

In addition there must be the reduction, through the general use of higher standards of highway design, of the current fantastically high accident potentials. The astronomical number of accidents that do not happen is terrifying. As traffic volume increases, the accident possibilities—that is, the pressures for accidents—build up in geometric ratio. The accident potentials can only be reduced with certainty by reducing the possible conflicts of traffic units.

We know that major reductions in the fatality rate can be made by providing properly designed, modern highway facilities, as is evidenced by the record of highways on which the accident potentials are greatly reduced. The following highways carry large volumes of traffic but have fatality rates as low as one-fifth to one-third of the national average because of the controlled-access design in which conflicts of all kinds—cross traffic, pedestrians, and traffic entering along the roadsides—have been materially reduced or eliminated:

	Death rate per 100 million vehicle-miles
Merritt and Wilbur Cross Parkways (1946)	2. 5
Chicago Outer Drive (1946)	2. 9
Riverside Drive, California (1941–44)	3. 0
Arroyo Seco Parkway (1941–44)	3. 9
Metropolitan New York Parkway System (1938–48)	2. 5
Pentagon network, Washington, D. C. (1942–48)	1. 5

The Pentagon network is composed of 17 miles of one-way through roads, 7.7 miles of one-way connecting ramps, and 2.3 miles of two-way local service roads—a total of 27 miles—on which travel for the period of slightly more than 6 years since its construction is estimated at 337,500,000 vehicle-miles. Five persons, three of whom were pedestrians, have been killed during this period. Further reference will be made to the observations of driver behavior on the roads of this system.

Under the inspired, at times militant, leadership of Mr. Robert Moses, the Metropolitan New York Parkway System has set an example of highways designed on a scale commensurate with traffic requirements of reasonable speed with safety. The system, steadily expanding, now consists of 164 miles of multilane roadway, much of which is divided. The obstacles which have been met are somewhat indicated by the required 208 bridges. There are two details of design, which cannot be over-commended, that have been or are being put into practice as safety measures. One is the installation of center curbs on the earlier undivided parkways: these have successfully eliminated the deadly head-on collisions. The other is the installation of paving blocks to support heavy vehicles on the shoulders when disabled.

The Action Program of the President's Highway Safety Conference lays great and proper stress upon the acceptance of individual responsibility for safety on the highways. Educators are increasingly stressing the importance of "true personal participation" in contrast to activity unrelated to the subject of study. Contrariness and individualism in respect to a desirable course of conduct disappear once the individual accepts his responsibility for safety of himself and others on the highway.

The responsibility of the individual toward the public to preserve highway safety should be activated by school instruction, town meetings, community forums, local coordinating and action committees, support by the press, discussion groups—all of which are calculated to impress the individual with his responsibility to the public and in this way mold or remold the habits and attitudes relating to safety on the highways.

When these approaches to the problem of accidents have been used, there still remains the very pertinent query, "What is the proper attitude of the public toward the driver?" Basically, the individual driver has his limitations of habits, of capabilities, and the handicaps of his own perception and reaction times. Each driver in a stream of traffic loses his freedom of action in a high degree, and is circumscribed by the actions of others. His performance is limited by, and becomes part of, the traffic flow, which is a composite of the reactions of a multitude of drivers. Thus the responsibility of the public to the individual driver is, first, to determine the characteristics of traffic flow lines, and second, in harmony with this knowledge, to provide the facilities

Table 2.—*Effect of commercial vehicles on practical capacities of multilane highways*

Proportion of commercial vehicles to total traffic	Percentage of passenger-car capacity on flat terrain	
	Flat terrain	Rolling terrain
Percent	*Percent*	*Percent*
None	100	100
10	91	77
20	83	63

for safe use. The dynamics of these speeding streams of traffic most directly influence the design features which we term geometric. These are alinement, profile, plan of intersection, clearances, horizontal dimensions of the highway cross section, and the many details which we group under the general term of highway design.

PRINCIPAL HAZARDS OF THE DESIGN CHARACTERISTICS OF EXISTING HIGHWAYS

The outstanding hazard of our streets and highways is undercapacity for the traffic load. Nearly half of the rural highways carrying 1,000 vehicles per day and over are less than 20 feet in width. On each mile of such highway, over 60 times per hour, or once each minute, a vehicle is encroaching upon the left lane when meeting an oncoming vehicle. Expanding these figures to the many miles of rural highways in this country, the accident potential reaches unrealized dimensions. The length of time that a vehicle in passing another vehicle occupies the lane used by the oncoming traffic, depends upon the width of pavement. On an 18-foot pavement vehicles occupying the left lane require 43 percent longer in passing than on pavements 24 feet wide. The pavement of the lesser width is not only more hazardous, but provides only 70 percent of the capacity of the 24-foot pavement.

Adequate shoulders are necessary to the efficiency of motor-vehicle operation. They are effective in increasing the traffic capacity of the highway, since bituminous-treated shoulders 4 feet or more in width adjacent to 18- and 20-foot pavements, as compared with grass or gravel shoulders, increase the effective surface width approximately 2 feet. Increasing the effective pavement width results in fewer vehicles encroaching upon the left lane of traffic, and thus increases the traffic-carrying capacity of the highway.

Shoulders also play a very important role in accident prevention in both rural and suburban areas where pedestrians are involved. In 1947, 25 percent of all rural pedestrian fatalities occurred while pedestrians were walking on the roadway. Were adequate shoulders available of the character necessary to provide usable footpaths, many lives would be saved.

To gain the advantage of adequate shoulders, there should be no vertical obstructions such as retaining walls, bridge trusses, utility poles, guard rails, parked vehicles, or other objects near the traveled way. Obstacles at the edge of a 10-foot lane cause vehicles to travel 2.6 feet farther from the edge of the pavement than when the obstacles are not present. Even for lanes 12 feet wide the same positioning of obstacles causes vehicles to travel 1.8 feet farther from the pavement edge. Obstacles 4 feet or more from the pavement edge have only minor effect. The roadside obstacles, therefore, have the effect of reducing the pavement width.

Adequate width of shoulder and a suitable surface for parked vehicles are necessary for every highway regardless of its width. On the Merritt Parkway in Connecticut, two-thirds of the fatalities resulting from collisions between vehicles have involved a parked vehicle on the roadway. The German Autobahnen were built with divided paved roadways, each 29.25 feet in width, thus providing capacity greatly in excess of normal requirements. The shoulder width was 1 meter. In 1938, after a very few years of use of a limited mileage, Inspector-General Dr. Fritz Todt, the official in charge, stated that the decision had been made to add wider shoulders because of numerous accidents caused by vehicles standing on the pavements. This experience is compelling in establishing proof of the danger inherent in the vehicle parked on the roadway. Every other element which we rate as contributory was absent, and the standing vehicle per se was the cause of the accidents.

Table 3.—*Average spacing between vehicles following other vehicles closely in the same lane at the same speed* [1]

Speed	Distance of travel per second	Two-lane highways		Four-lane divided highways			
				Left lane		Right lane	
		Distance spacing	Time spacing	Distance spacing	Time spacing	Distance spacing	Time spacing
M. p. h.	*Ft./sec.*	*Feet*	*Seconds*	*Feet*	*Seconds*	*Feet*	*Seconds*
10	14.7	30	2.04	----------	----------	----------	----------
20	29.3	42	1.43	----------	----------	----------	----------
30	44.0	62	1.41	60	1.36	80	1.82
40	58.7	90	1.53	77	1.31	105	1.79
50	73.4	122	1.66	107	1.46	130	1.77
60	88.0	162	1.84	139	1.58	156	1.77

[1] Spacing measured from the rear bumper of one car to the front bumper of the following car.

Where sight distances on two-lane roads are so short that passing would be hazardous, it is customary to stripe no-passing zones. Observations were made on a 3,400-foot length of highway, of which about one-fourth was marked "no passing" by reason of sight distances below 400 feet. Of the total number of passings made within this 3,400-foot length, more than 10 percent were started or completed in the restricted zone. On roads where no-passing restrictions comprise as much as 40 percent of their length, the volume of traffic that can be satisfactorily and safely accommodated is only about 80 percent of that which can be carried on a similar highway free from sight distance restrictions.

The road margin is the critical line of hazard on many of our existing highways. Recognition of this situation appears in a project just initiated in Michigan, in which a study of the locale of accidents with respect to taverns, gas stations, restaurants, and other roadside establishments is to supplement the more conventional facts analyzed in studies of traffic accidents. The unrestricted use of the road margin for entrance and exit at such locations causes driver confusion, disorderly parking, and other operating hazards. The growth in the number and popularity of outdoor drive-in theaters is but a single example of the commercial exploitation of the roadside. The safety of motoring audiences, as they enter or leave these establishments in large numbers, has become a necessary concern of highway authorities because of the effect on operating conditions on the adjoining highways. The most difficult obstacles the highway engineer faces in his effort to build safety into the highways are the lack of legal authority and effective legal machinery provided to acquire sufficient right-of-way and to control the entrance to the public highway from abutting property.

A characteristic serious fault of drivers is that of following too closely a car traveling in the same lane. The speed and the interval between the cars do not permit adequate perception and reaction time for the rear car to stop if the car ahead is brought to an unexpected halt. This type of accident has the potentials of a whole series of accidents, of tying up traffic, of causing much property damage, and sometimes serious or fatal accidents. The grave implications of this very common practice are indicated in table 3. The perception and reaction times vary with individuals, but a safe assumption would hardly be less than 1.5 seconds. Tests of drivers have shown that the minimum reasonable reaction time alone is three-fourths of a second.

The average time spacing between vehicles following at the same speed, for all speeds and for both two- and four-lane roads, is 1.58 seconds; 16.2 percent of the traffic will have a time spacing of 0.75 seconds or about one-half the average.

THE COMPONENTS OF ROAD DESIGN FOR SAFE OPERATION, AS INDICATED BY DRIVER BEHAVIOR

Alinement

The alinement must be adjusted to the volume and type of traffic, the driving characteristics of the operators, and the dynamic effects of the mass movement. The alinement selected, whether the highway be two, four, or more lanes wide, determines how effectively and safely the completed facility will meet the demands of traffic. Sight distances between 1,500 and 2,000 feet long are essential on any rural two-lane highway. The percentage of the length where sight distances of this magnitude should be available will depend on the volume and type of traffic which the highway must accommodate. On our main highways carrying high-speed through traffic, a sight distance of at least 1,500 feet should be available on a

The need for wide shoulders is evident here.

minimum of 60 percent of the route length if the highway is to accommodate peak traffic volumes as high as 500 vehicles per hour with safety. If it is unavoidable to introduce curvature which restricts the sight distance, it is essential to select an alinement free from sudden changes that come as a surprise to the operator. Curves at the ends of long tangents are definitely more hazardous than the same curves located where the general alinement is made up of a series of curves.

Practical Working Capacities

Accidents are inevitable on overloaded highways. Safe highways must have sufficient capacity to permit drivers to operate at reasonable speeds. On main rural highways drivers generally accept, as reasonable, average running speeds of 45 to 50 miles per hour during the peak volumes. On urban expressways, a speed of 30 to 35 miles per hour during peak traffic volumes is reasonable.

The working capacities for modern rural roads in terms of passenger cars per lane are 450 per hour for a two-lane road, and 1,000 per hour for the lanes in the direction of heavier travel on multilane roads. At these traffic volumes, under ideal roadway conditions, the drivers who so desire can safely travel at a speed of 45 to 50 miles per hour on rural roads, although the average speed of all vehicles at any given point will be about 42 miles per hour as compared to an average speed of about 48 miles per hour during low traffic densities.

In urban areas the maximum practical working capacity for a modern multilane expressway is 1,500 passenger cars per hour for each lane in the direction of heavier travel. At this volume, drivers who so desire can safely average 35 to 40 miles per hour, and the average speed of all vehicles will be between 30 and 35 miles per hour. At this working point, unusually high volumes that occur frequently for short periods can be handled without complete congestion.

Lane Widths

The lane widths used for the design of our highways must be based on vehicles in motion; not on the actual size of the vehicles standing still. Most of our main highways have sufficient traffic of commercial vehicles to require 12-foot lanes for safe operating conditions. Eleven-foot lanes must only be considered for highways carrying less than 1,000 vehicles per day. The reduction in capacity by narrowing lanes is not only unsafe; it is definitely uneconomical—the cost of the additional width is less than the proportional increase in capacity. The effect of lane width on capacity is shown in table 4.

Two-Lane Highway Limitations

The accident experience on two-lane highways shows that the death rate per million vehicle-miles increases with an increase in the traffic volume. Operating conditions on the average two-lane highway are not satisfactory when traffic volumes exceed 4,000 vehicles per day in flat terrain, or 3,300 vehicles per day in rolling terrain. It is only for extremely low daily traffic volumes that a two-lane highway can safely accommodate a vehicle traveling over 60 miles per hour, regardless of excellent alinement. Design speeds that exceed 60 miles per hour, to provide safe operating conditions, require four-lane divided highways if the volume exceeds 3,000 vehicles per day. On free-flowing highways where the higher speeds are safer, this very fact automatically lowers the top range by permitting a constant rate which satisfies most drivers. The average actual rate for two-lane highways of modern superior design is about 48 miles per hour.

There is confusion of the terms "overload" and "congestion." Congestion approaching stagnation may lower the frequency of serious accidents, but at the same time it defeats the utility of highway transport. Any concept that congested highways are safer completely overlooks the fact that each route has its own characteristic pattern of daily use. It may have an hour or a fraction of an hour of congestion once or twice daily, at peak traffic periods. These periods of congestion causing stagnation or incipient stagnation may be productive of numerous but not fatal accidents. The remainder of each 24 hours constitutes 90 to 95 percent of the time, during which there are much longer periods when the route is overloaded and a breeder of accidents.

Multilane Highways

Multilane highways of the divided type will accommodate three to six times as many vehicles per lane as a two-lane highway, and provide greater safety. For average conditions, the width should be increased from four to six lanes when the volume exceeds 18,000 vehicles per day in rural areas, or 32,000 vehicles per day in urban areas. In certain areas of the country where seasonal, daily, and hourly fluctuations in traffic flow vary from the average condition, the practical capacity of a four-lane divided highway might be as much as 30 percent higher or lower than the above volumes.

Shoulders are Essential

Shoulders that will accommodate disabled vehicles and that may be used by moving vehicles in cases of emergency, during any weather conditions, are essential for safety on main highways. Adequate shoulders are also essential to realize the full capacity of the surface width. Without adequate shoulders, one disabled vehicle can reduce the capacity of both two-lane and multilane highways during peak periods by as much as 60 percent. There is at least one disabled vehicle for every 20,000 vehicle-miles of travel on our main highways.[2] Furthermore, adequate shoulders increase the effective surface width for traffic when no disabled vehicle is present. Without a place of refuge outside the traffic lanes, one disabled vehicle can reduce the capacity of a highway by more than one lane, especially if the lanes are less than 12 feet wide.

The disabled vehicle blocks one lane and reduces the capacity of adjoining lanes by restricting vehicle speeds. It may block all lanes in one direction, completely stopping traffic in that direction. The maximum capacity of a traffic lane with vehicles moving at 20 miles per hour is only 87 percent of its capacity at 30 miles per hour; at 10 miles per hour, only about 50 percent. A minor accident which causes a reduction in speed can result in complete congestion when a facility is operating near its capacity.

Table 4.—*Effect of lane width on capacity*

Lane width	Percentage of 12-foot lane capacity		
	Two-lane rural roads		Multilane expressways at practical urban capacities
	At possible capacities	At practical capacities	
Feet	*Percent*	*Percent*	*Percent*
12	100	100	100
11	88	86	97
10	81	77	91
9	76	70	81

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[2] On the Oakland Bay Bridge, for example, during the peak hour when 6,700 vehicles use the 6-mile structure, an average of two vehicle break-downs can be expected, which will seriously affect the traffic capacity of the bridge.

Curbs and Lateral Clearances

Any vertical member adjacent to a roadway constitutes a safety hazard and is an obstruction to the free movement of traffic, unless it is 6 feet removed from the pavement edge. High vertical curbs of the so-called nonmountable type fall within this category, and when required they should be 6 feet removed from the traveled way in order to have no effect on traffic. If they are 3 or 4 feet away, however, their effect will not be critical. A low sloping curb may be used adjacent to the roadway surface in conjunction with a high curb further removed.

Drainage

The provision of side ditches, gutters, and drainage structures, sufficient to prevent mud and debris from washing onto or collecting on the roadway surface during storms, is a necessary safety measure. Such foreign materials constitute hazards in themselves by creating slippery pavement conditions; but of greater importance is the hazard created by drivers who, in attempting to avoid such materials, bring their vehicles into the paths of other vehicles. In the colder regions the formation of ice on pavements as a result of water collecting in poorly drained places presents a serious safety problem.

Highway Intersections

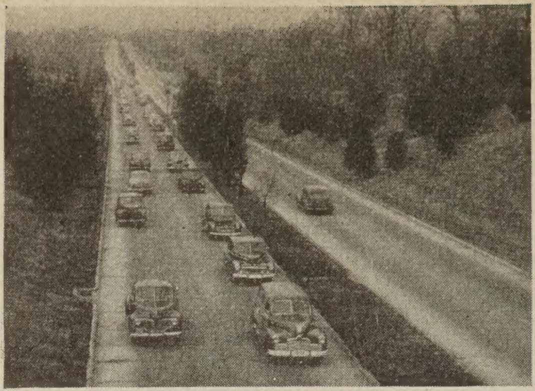
To provide safe operation at intersections, on rural through roads carrying an average traffic of 5,000 vehicles per day and over, the grades should preferably be separated at intersections with other major roads.

Chief among the reasons for safety violations at intersections is congestion. The driver whose patience is exhausted is here the dangerous operator. Aside from relief of congestion, there are a number of measures that aid in minimizing hazards at intersections. Among these measures the following rank high:

1. Corner sight distances consistent with the operating speeds of traffic, with due consideration of the method of traffic control employed.
2. Safety islands for pedestrians at busy intersections where streets are wide and pedestrian traffic is heavy.
3. Separated turning lanes, especially on high-speed or moderately high-speed divided highways, to enable turning vehicles to decelerate and stop, if necessary, clear of the lanes used by through traffic.

Railroad Grade Crossings

All main-line railroad grade crossings of highways which carry substantial traffic flows should be separated. Because of the cost and the pressures for other highway improvements, the elimination of crossing hazards by construction of separation structures will be delayed at many locations. Consequently, grade-crossing protection should proceed rapidly. Particularly effective are the installations of the short-arm automatic gates. These have some obvious maintenance and cost advantages over the long-arm gate installations, and provide a barrier which experience has proven adequate. Though the combined short-arm gate and flashing signal installation is somewhat more expensive than that of the flashing signal alone, this type should be uniformly used for all main-line crossings at grade, regardless of the number of tracks. This position is reflected in the present policies of the Public Roads Administration.



An accident a mile away resulted in this concentration of traffic.

Loading Recesses

The destined function of practically all of our highway mileage, both new and old, is to provide service to all classes of traffic. The peculiar needs of commercial and mass-transit vehicles, not only in their steady flow movements but also at their terminals, transfer points, and roadside stops, require attention in shaping the physical features of the roadway. The frequent stopping of transit or commercial vehicles in the moving traffic stream is a serious traffic hazard. Wherever possible, and in all instances on new highways designed as routes for mass transit, proper facilities should be provided off the through lanes for transit-vehicle passenger loading and unloading. These roadways should be designed to expedite movements of the transit vehicle as well as those of the more numerous private passenger car.

Through the provision of more attractive and convenient mass transportation, there is the possibility of shrinking our urban traffic problems to more moderate limits. Efficiently designed off-street loading bays and terminals for trucks serve a similar purpose, particularly in the central core of our cities where street space is wholly inadequate for the moving traffic.

Uniform Signs and Signals

Traffic-control devices, though relatively inexpensive accessories to street and highway design, are significant aids to safe highway operation. Well designed and located highway signs, signals, and markings eliminate or relieve many of the elements of surprise that characterize certain combinations of design and traffic-operation features. The planning of new highway facilities should always be accompanied by thought as to the traffic control, to hold restrictive measures to a minimum. Such preliminary considerations also offer certain correlative benefits in the joint planning of design and control elements on the new facility. The control will thus be tailored into the design at the most appropriate stage, and not left for piecemeal application after completion of the construction. The Manual on Uniform Traffic Control Devices should be rigorously followed. The manual has become the single legal standard for use on all Federal-aid projects.

Speed Control

Reasonable speed is a necessary element of efficient highway transportation, yet speed is so frequently pointed to as a traffic accident cause that the dictum has wide acceptance that traffic accidents and higher speeds go hand in hand, and that there can be no one facility that possesses the characteristics of speed and safety. Numerous attempts to relate speed and accidents have had but meager success. Speed definitely increases the severity of accidents, and it has been demonstrated from studies in New York, New Jersey, and Connecticut that fast drivers are guilty of more traffic violations and are involved in more accidents than those who operate at more moderate speeds. But we also find that our modern highways with excellent safety records are accommodating traffic speeds definitely above those found on routes of inferior design.

The answer is certain. The newer facilities have been purposely planned to meet the higher speed demand, and are distinguished by uniformity in those design features that relate to safe accommodation of faster-moving traffic.

Safe vehicle speeds thus depend in large measure on characteristics of the roadway. With approximately 400 billion vehicle-miles of travel annually, it can hardly be expected that police activity on speed-law enforcement will be effective for more than a small fraction of this total. Speed controls, where applied, must be adapted to the circumstances. On our highway systems, both urban and rural, there is a wide range of ability to accommodate speed. This is true not only for the nation but for any State, or for any appreciable length of highway within a given State.

Thus, the establishment of a uniform legal speed limit for rural and urban areas is not a solution. Such a policy is unsound. A limit set at the maximum safe speed for the poorest section of highway is obviously an invitation to disregard the law. As shown in table 5, 37 of the States now exercise the authority to post speed limits differing from the speed that has been set as a general maximum. The

Table 5.—*State-wide speed limits and speed zoning authority*

Rural State-wide speed limit	Number of States	States with rural speed zoning authority
No limit	14	10
60 m. p. h.	8	8
55 m. p. h.	7	7
50 m. p. h.	10	7
45 m. p. h.	4	3
40 m. p. h.	2	0
35 m. p. h.	2	2
25 m. p. h.	1	0
	48	37

Table 6.—*Suggested zone speeds for safe operation on curves*

Degree of curvature	Radius of curvature	Suggested zone speed[1]
	Feet	*M. p. h.*
3	1,910	60
4	1,433	53
5	1,146	48
6	955	43
7	819	40
8	717	37
9	637	35
10	574	33
11	522	32
12	478	31
13	442	30
14	410	29

[1] Before zoning speeds are posted the curves should be tested by competent observers to determine the safe speed for the particular conditions.

rural State-wide daytime limits range from 25 miles per hour in 1 State to no limit in 14 States. Of the 29 States having general limits above 50 miles per hour, all but four are using the device of zoning to encourage judicious use of the highway with respect to speed. Much more needs to be known about the principles of successful zoning, but sufficient study has been given to determine that the signing must be realistic and possess considerable self-enforcing value. The establishment of frequent, unwarrantedly low limits breaks respect for the entire zoning device, which is reflected in abuses of other essential traffic regulatory measures. Suggested zone speeds for safe operation on curves are shown in table 6.

Efficient Operating Grades for Trucks

Table 7 shows the distance that light-powered trucks with gross weights of 30,000 pounds, and medium-powered trucks with gross weights of 40,000 pounds, can go up various grades before their speeds are lowered to 30 miles per hour. Medium-powered trucks with gross weights of 40,000 pounds will probably not occur with sufficient frequency on most of our main rural highways to justify basing the road design on these vehicles alone. Light-powered trucks with gross weights of 30,000 pounds, however, will occur with sufficient frequency on most main highways to affect seriously the operation of passenger vehicles on the highway unless they are considered when selecting the alinement and other design features of the road. It will be noted that the length of grade that reduces the speed to 30 miles per hour is approximately the same for the light-powered trucks with the gross weights of 30,000 pounds as for the medium-powered trucks with gross weights of 40,000 pounds.

A third lane on the uphill side will prevent the slow-moving trucks from unduly interfering with other traffic if the third lane is started at the proper distance from the bottom of the grade, as shown in table 7. In certain types of terrain, however, especially where the road is located on the side of a steep hill or mountain, it may be impractical to provide an additional lane. Since the problem must be met on main routes, there are the alternatives of improved alinement for routes of light travel, or the addition of a new one-way, two-lane roadway on a separate location. In the latter case the old plus the new roadway would provide two lanes in each direction.

Far too little attention is given the fact that farm production is moving to the markets and to the railroads in trucks. In a constantly increasing degree the secondary or farm-to-market roads must be designed for truck operation; and efficient, safe operation requires low gradients. The lowest unit-cost item in road construction today is earth excavation, and there is no reasonable excuse to neglect the economy that will accrue to the farms by requiring additional excavation in designing farm-to-market roads, to provide low grades and good alinement.

From the angle of safety only, the most serious result of grades is the restricted sight distance at the crest, or of the erroneous design policy, quite generally practiced, of introducing short sight distance curves to lower the percentage of gradient.

The Less-than-Traffic-Speed Driver

On week ends and holidays the most fervent anathemas of other drivers are directed toward the driver who fails to maintain the average traffic speed. This attitude mistakes the effect for the cause. The collection of a queue of cars with frustrated drivers behind a car moving slower than the average traffic speed is a sure indication of an overloaded highway. The same conditions apply as in the case of the slow-moving truck. The fault is the highway, not the slow driver. Too narrow traffic lanes and too restricted sight distances are the most common defects. The slow driver is not likely to disappear from the roads; the remedy lies in eliminating his accident potential by improved road design.

Capacities of Express Highways

At the present time our main highways carry about 20 percent commercial traffic. During peak hours, however, commercial vehicles are generally in the neighborhood of 10 percent of the total traffic. In rural areas, two-thirds of the traffic is generally in one direction during the peak hours. In urban areas, the distribution by direction will generally vary from two-thirds in one direction in the outlying areas to an equal distribution each way in the central business districts. It is generally not feasible to obtain a perfect alinement having no sight distance restrictions, on two-lane highways. Even in flat terrain it is difficult to obtain more than 80 or 90 percent of the road with a sight distance over 1,500 feet, and in rolling terrain it is difficult to obtain more than 60 percent of the road with a sight distance over 1,500 feet. The total hourly capacities for two- and four-lane highways in rural and urban areas, for these average conditions, are as shown in table 8.

Table 7.—*Distance from bottom of grade at which truck speed would be reduced to 30 miles per hour*[1]

Grade	Light-powered trucks with gross weights of 30,000 pounds		Medium-powered trucks with gross weights of 40,000 pounds	
	Distance from bottom of grade	Vertical climb	Distance from bottom of grade	Vertical climb
Percent	*Feet*	*Feet*	*Feet*	*Feet*
2	2,000	40	1,780	36
3	1,090	33	1,035	31
4	760	30	740	30
5	570	29	550	28
6	470	28	450	27
7	400	28	390	27
8	325	26	320	26

[1] Assuming an approach speed of 40 miles per hour. Bad alinement, weak and narrow bridges, or other hazardous conditions at the bottom of the grade would make these speeds unsafe.

Table 8.—*Hourly and annual average 24-hour design capacities for express highways*[1]

Type of area and terrain	Hourly design capacities		Annual average 24-hour design capacities[2]	
	2-lane highway	4-lane highway	2-lane highway	4-lane highway
Rural areas:[3]				
Flat terrain[4]	600	2,800	4,000	18,700
Rolling terrain[5]	500	2,500	3,300	16,700
Urban areas:[6]				
Flat terrain[4]	---	4,550	---	38,000
Rolling terrain[5]	---	3,850	---	32,000

[1] Based on 10 percent commercial vehicles during peak hours.

[2] Based on a 30th highest hour of 15 percent of the annual average 24-hour traffic for rural areas, and a 30th highest hour of 12 percent of the annual average 24-hour traffic for urban areas.

[3] Based on two-thirds of the traffic in one direction and an operating speed of 50 m. p. h.

[4] Based on sight distance of at least 1,500 feet on 80 percent of the 2-lane highways.

[5] Based on sight distance of at least 1,500 feet on 60 percent of the 2-lane highways.

[6] Based on 60 percent of the traffic in one direction and an operating speed of 35–40 m. p. h.

When relating the hourly design capacities to annual traffic volumes, fluctuation in traffic flow must be considered. Comprehensive studies of the fluctuation in traffic flow on rural highways show that the traffic density somewhere between the thirtieth to the fiftieth highest hourly traffic volumes of the year should be selected for design purposes. On the average rural highway, the thirtieth highest hour of the year is about 15 percent of the annual average 24-hour traffic volume. In urban areas it averages about 12 percent of the annual average traffic volume. Table 8 shows the annual average 24-hour traffic volumes that can be used for design purposes at locations where there is the average fluctuation in traffic flow. Values as much as 30 percent higher or lower than these may be applicable to a specific location, depending on the seasonal, daily, and hourly fluctuation, and the distribution of peak-hour traffic by directions.

A four-lane expressway of modern design, with controlled access, will accommodate as much traffic, at approximately twice the average speed, as—

1. Five ordinary city streets, each 40 feet in width, with parking prohibited.
2. Eight ordinary city streets, each 42 feet wide, with parking on both sides.
3. Five ordinary city streets, each 68 feet wide, with parking on both sides.

4. About three ordinary city streets, each 68 feet wide, with parking prohibited.

By "ordinary city streets" is meant those that have the average amount of left-turning movements and pedestrian interference prevalent in downtown areas.

Brakes

The hazardous conditions created by too short spacing between cars following in the same lane are emphasized by the studies of brake performance. Safe vehicle performance depends to a greater degree upon adequate, well-maintained brakes than upon any other single element of vehicle design. Likewise, the brakes betray most surely the failures and neglect of the driver or owner. Studies by the Public Roads Administration just before the war disclosed that over 40 percent of the passenger cars tested on the highway had zero pedal reserve, i. e., the pedal was flat on the floor board after an emergency stop from 20 miles per hour.

Brakes are a common alibi in many accidents; sometimes the true cause, but more often not. If the brakes fail, the responsibility lies usually with the driver. He has not maintained them properly.

The widely distributed studies of brake performance show that the condition existing in 1942 was not a rosy one. It is probably worse today. Only 62 percent of the passenger cars, 18 percent of the two-axle trucks, and 3 percent of the three-axle combination units could stop in 30 feet or less from a speed of 20 miles per hour.

There is abundant confirmation that the braking systems of passenger cars and especially of commercial vehicles are too commonly poorly maintained or grossly inadequate. An analysis of the results indicates that this level of performance can be greatly improved. Passenger cars and two-axle trucks can be made to stop from 20 miles an hour in 30 feet or less. The combination units now on the road may not be able to do that well, considering the lag that exists from the time that the pedal is touched until the brake shoes actually contact the drums. However, it is certain that with proper maintenance of well-designed braking systems, a much better showing can be expected. It is heartening, in this respect, to read that the Pennsylvania Motor Truck Association's Engineering Subcommittee has been able to stop a 62,000-pound, two-axle tractor and tandem-axle semitrailer in an average distance of 27¾ feet, from 20 miles per hour. There is every indication that the automotive engineers who cooperated in the tests have succeeded in reducing to a marked degree the inherent brake lag.

The tests of vehicles as they are now operating on the roads clearly show that the proper maintenance of brakes is not as yet being generally accomplished, and that a more stringent enforcement policy is necessary.

The importance of brakes in relation to driver behavior is emphasized by the data in table 3, showing distance spacing and time interval between cars traveling in the same lane. If the driver behind has instant perception time (which is impossible) and the average reaction time of three-fourths of a second, and if his speed is only 30 miles per hour, he has two-thirds of a second for his brake to stop his car if the car ahead stops suddenly. Under such typical circumstances, when an accident occurs do the driver's brakes fail to work or does the driver fail to work the brakes? The answer is one major reason why insurance rates are going up.

THE PARADOX OF DRIVER BEHAVIOR

"We know so much about roads that is not so," has long handicapped correct thinking. We do know now much of driver behavior that without positive proof we think could not be true. For example, the relationships of accident frequency and accident potentials with the details of highway design have been described. The accident rate on two-lane rural highways carrying less than 1,000 vehicles per day is approximately half that on similar highways where the volume is in the range of 8,000 or more vehicles per day. That is, on overloaded highways or underdesigned highways the accident rate increases with traffic volume. On such highways, we would logically think drivers would become more careful. Paradoxically, driver behavior becomes worse as the road becomes more inadequate to carry safely the traffic volume. Under conditions where the driver should become more responsible he becomes less so. Contrariwise, evidence supports the conclusion that as the standard of design is raised, driver performance becomes more responsible. This observation of driver behavior undoubtedly reflects the ability of the average mind and nerves to function more safely if tension beyond necessary alertness is relieved and apprehension is absent.

Here is the record of traffic operation that has emerged from the studies on the Pentagon network of roads over the past 6 years. The system was designed and built by Public Roads to serve an estimated population of 50,000 office workers in the new defense establishments, all of which were transferred almost overnight across the Potomac River to a previously unoccupied area in Virginia. The problem was to move the major part of this population in and out daily by motor vehicle over the existing three Potomac River crossings—Key Bridge, Memorial Bridge, and Highway Bridge.

Excluding the traffic over Memorial Bridge which uses Lee Boulevard, and other traffic which does not actually traverse a portion of the 17 miles of through routes, it is estimated that there are now 85,000 trips per day on the Pentagon system. Including the traffic on roads immediately tributary to the system, there are about 110,000 trips on these roadways daily. This is a conservative figure, since the three bridges which the system serves are now carrying an average traffic of more than 139,000 vehicles per day and a peak-month traffic of 149,500 vehicles per day. The system now produces about 67 million vehicle-miles of travel per year. In the 6-year period, five fatalities have resulted from this operation, three of whom were pedestrians. Only one fatality was caused by a vehicle traveling at a relatively high rate of speed, leaving the road and overturning. For this 6-year period the accident rate was 1.5 fatalities per 100 million vehicle-miles. In this experience lies the assurance of what can be accomplished through safe road design, but the record of driver behavior is the astonishing feature.

During the war there was a speed limit of 35 miles per hour on both the Pentagon network and on the Shirley Highway which extends southward from it. The 35 m. p. h. speed signs were not removed until several months after the war. Prior to their removal, speed studies were conducted at several points on the network and on the Shirley Highway. These studies were repeated after changing the 35 m. p. h. signs to speed limit signs of 40 m. p. h. on the network and 50 m. p. h. on the Shirley Highway. Changing the speed limit on the network from 35 to 40 m. p. h. had no effect on the average speed, but reduced the number of vehicles traveling over 50 m. p. h. by 11 percent and those going over 40 m. p. h. by 20 percent. Changing the signs on the Shirley Highway from 35 to 50 m. p. h. reduced the number of vehicles traveling over 50 m. p. h. by 32 percent.

On the through routes of the Pentagon network, where there are no traffic police, no traffic-control lights, and no enforcement of the 40 m. p. h. posted speed limit, the average speed is 37.6 m. p. h., and 12 percent of the vehicles exceed 45 m. p. h. On nearby Lee Boulevard, where safe speeds are much lower and the posted speed limit of 35 m. p. h. is enforced by frequent patrolling by traffic police, the average speed during light traffic volumes is 37.8 m. p. h., with 11 percent of the vehicles exceeding 45 m. p. h. and 36 percent exceeding 40 m. p. h. Thus on the network, where drivers can legally maintain reasonable speeds at all times, they travel no faster without enforcement than they do on Lee Boulevard, where safe speeds are not as high and the normal enforcement is present. Furthermore, three times as high a percentage of the drivers exceed a 5 m. p. h. tolerance of the posted limit on Lee Boulevard as on the Pentagon network.

The present traffic volume on the network is 800 vehicles per hour per lane at locations where three lanes are available for movement in one direction. At the principal mixing lanes, a flow of 1,150 vehicles per lane occurs where four lanes are available for one-direction movement. The principal mixing lanes are now loaded to their possible capacity at certain peak periods. Other points on the network are loaded to approximately two-thirds of their practical safe capacities. All three of the Potomac River bridges are loaded beyond their practical, safe capacities, and at times the demand actually exceeds the possible capacity of the bridges with their present approaches. The condition will be relieved materially by the completion of the two four-lane, one-way bridges now under construction.

DESIRE LINES OF TRAVEL

In harmony with the premise that roads must be designed on a basis of driver behavior is the relatively new technique of planning the system of arterial roads to serve the heavy flow lines of metropolitan areas on the basis of origin and destination surveys. These surveys disclose the desire lines of major travel. The pattern which emerges is that of a wheel, usually somewhat distorted in shape, but essentially providing radial lines from the urban center which are joined by concentric circles at spaced distances from the center. The concept has the two major objectives of providing free-flowing arterial routes in and out of the center, and of separating through, longer-distance traffic from local vehicle and pedestrian interferences. Also, such a plan will keep a high percentage of the total traffic out of the more congested center of the city. Driver behavior can be relied upon to exercise a high selectivity of route if the facilities provide a choice. Under such circumstances the driver will choose the route that will give him the most direct access to his destination, but at the same time will give him the shortest distance of travel through the more congested downtown streets.

The Pentagon system serves three bridges across the Potomac River, leading into the downtown streets of Washington. These bridges are interconnected by the system, and the driver from the Virginia suburban districts had, until the bridges became so congested as they are today, a choice among the bridges of that route which would require him to travel the least distance on, or would keep him off, the congested downtown city streets. The degree to which he accomplished this purpose without any imposed controls is amazing, as is shown by the data in table 9. The actual distribution is representative of the free choice of traffic between origins and destinations during a period when the traffic volumes were relatively low and there was not sufficient congestion on the bridges to alter the desired usage.

A study of the origins and destinations of traffic using the three bridges indicates that the slight percentage differences between the shortest routes and the actual routes used probably resulted from traffic routing itself, in its use of the three bridges, to the bridge that would permit the shortest travel distance on the Washington central city streets.

Table 9.—*Distribution of traffic on the Potomac River bridges*

Bridge	Actual distribution		Calculated shortest-route distribution [1]
	Aug. 16, 1944	Sept. 1, 1943 to Aug. 31, 1944	
	Percent	*Percent*	*Percent*
Highway Bridge	41.8	42.6	40.2
Memorial Bridge	33.0	31.5	32.7
Key Bridge	25.2	25.9	27.1
Total	100.0	100.0	100.0

[1] Assumed usage of shortest route between origin and destination.

HIGHWAY SYSTEM PLANNING

Finally, this discussion is directed to the essentials of today's program of highway improvement. Since 1934—nearly one and one-half decades—the State-wide highway planning surveys have been accumulating the facts of the amount and characteristics of the traffic use of our highways. State by State, undoubtedly more is known about the highways, their use, and their needs, than about any other major public undertaking. Until recently this wealth of material had not been generally analyzed and organized to serve its most important purpose as conceived when the surveys were started. In 1945 the California State Legislature, recognizing the need for a long-range highway improvement plan, established a study committee to organize the available material and to secure new data necessary to bring together a complete engineering and economic report. The completion of the report, the legislative recommendations, the legislative debate, and the adoption of the major recommendations, are now a part of the State's highway history. California has a well-rounded, long-term, modern highway improvement program. With this successful guide, many other States have now in active operation legislative study committees, which, with the competent technical assistance of the Automotive Safety Foundation, are maturing long-range programs of comparable caliber. The planning is designed to serve both economic needs and safety of use. Since the future reduction in highway fatality toll, as has been shown, will depend so largely upon safer roads, no effort by the Foundation can result in a greater contribution to highway safety.

There are also implications of vehicle design that can be well heeded. For example, it is certain the driver needs to have a better sight of the right-hand edge of the road. Protective bumpers, front and rear, capable of absorbing shock, are needed in place of expensive grillage which is going to suffer more in the future than in the past. Roads cannot be designed to prevent accidents caused by drivers following too closely, which are likely to involve a series of cars. Also, is it not time to forget the emphasis on minor over-speeds of the decent driver and concentrate on the driver who by his behavior creates accident hazards? The driver who passes in a no-passing zone, who parks his vehicle on the pavement, and who crowds the other fellow's lane is a killer. Why not take him off the road?

The purely routine speed checking is as futile and wasteful of enforcement officers' time and ability as is their detail to check on overtime parking, both of which only result in congestion in the traffic courts on matters having a minimum relation to real traffic safety. We need the time of the traffic officers and of the courts to take the dangerous driver off the roads. Only a very small percentage of drivers habitually disregard the rules of safe driving.

This matter of driver behavior goes very deep. It involves a psychology that may well be inherent in a people who have been, and are capable of, building and running the outstanding democracy of the world. It is the essence of the spirit of freedom which revolts against unfair or unreasonable restrictions but which is tempered in the large majority to support of the public welfare. So it seems reasonable to accept the pattern established by the behavior of the decent majority and deny the freedom of the road to the violator of this pattern. Safety of the highways is, as democracy is, a matter of cooperation and coordination.

(*Continued from page 153. Tables 14 and 15 are on page 155.*)

For each 1,000 trucks and truck combinations, the number of axles weighing more than the recommended limit was 42 in the Pacific region, 146 in the Middle Atlantic region, and 108 in the New England region. For truck combinations, corresponding figures are 114 for the Pacific region, 500 for the Middle Atlantic region, and 449 for the New England region. Eliminating the empty vehicles, there were in the Middle Atlantic and New England regions about two axle loads in excess of the recommended limit for each three loaded truck combinations.

Table 14 shows the number of vehicles per 1,000 vehicles of various types with an axle-group load in excess of the limits recommended by the A. A. S. H. O., and in excess of these limits by various percentages. For the country as a whole, of each 1,000 loaded and empty trucks and truck combinations, 25 had axle-group loads weighing in excess of the recommended limits, 12 of which exceeded the limits by over 10 percent. It was the truck combinations rather than the single-unit trucks that produced the high load concentrations since of each 1,000 combinations, 89 had axle-group loads weighing more than the recommended limits, of which 46 exceeded the limits by more than 10 percent.

Many vehicles were so loaded, of course, that they exceeded more than one recommended weight limit; and some vehicles had several axle loads weighing more than the recommended limits. Counting each vehicle only once, regardless of the number of particulars in which it exceeded the recommended limits, table 15 shows the number of vehicles per 1,000 (both loaded and empty included) of each type that exceeded the limits by various percentages. Those vehicles which exceeded more than one provision of the recommended restrictions were tabulated in the column showing the highest percentage excess for any item. In the United States as a whole, 59 vehicles out of every 1,000 were overloaded to some degree and 15 out of every 1,000 exceeded some one of the provisions by more than 20 percent.

The Effect of Tax Increases on Gasoline Consumption

BY THE DIVISION OF RESEARCH REPORTS
PUBLIC ROADS ADMINISTRATION

Reported by E. M. COPE, Chief, Highway Statistics Section, and L. L. LISTON, Assistant Highway Economist

The possible effect of increases in State gasoline-tax rates on the use of highways has always been a matter of concern to highway administrators and highway users. This article describes a study of the problem, considering tax-rate changes and their effects on gasoline consumption and motor-vehicle travel during the period January 1946–July 1948.

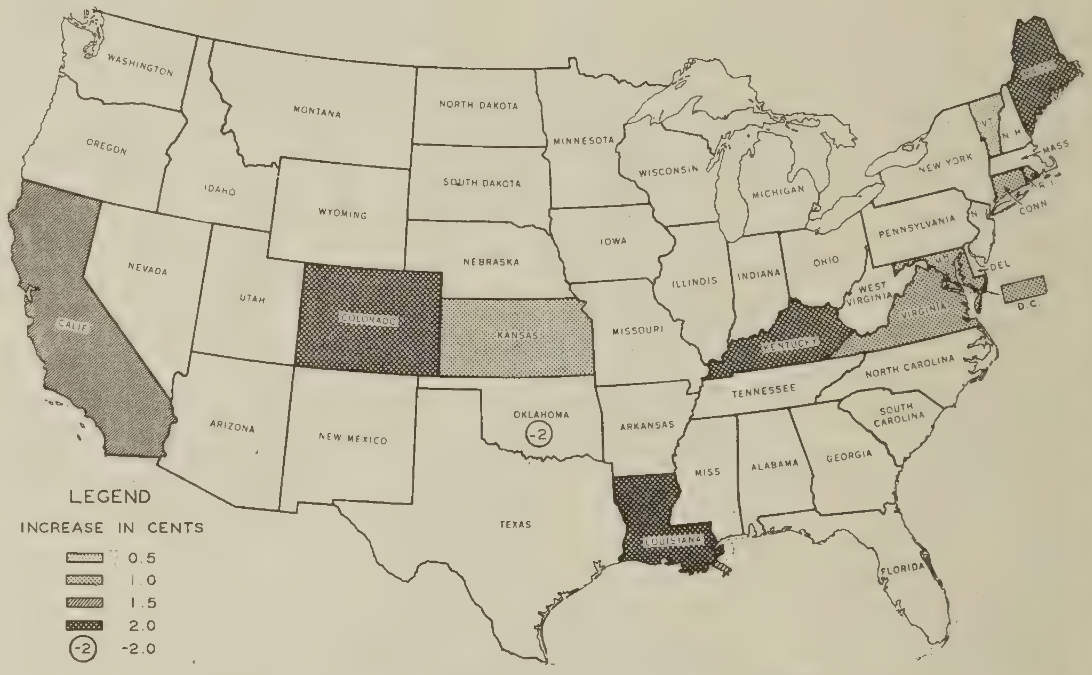
From an analytical standpoint, one of the principal difficulties encountered was the fact that there were parallel and much greater increases in the sale price of gasoline, excluding tax. The largest tax increase in any State in the 30-month period under study was 2 cents, while the smallest price increase was 3.5 cents. There were tax increases in only 12 States, but there were price increases in all States. Considerable fluctuation in gasoline sales was caused by "stocking up" just prior to the effective date of tax increases, with a consequent reduction in inventories immediately thereafter, thus creating the impression that the tax increase had reduced the consumption of gasoline.

It was found that consumption of gasoline in States where there were tax increases was similar in pattern to that in adjacent States where the tax was not increased. The increases in State gasoline tax rates, while causing substantial fluctuations in the sales of gasoline at the point at which it is taxed (the distributors, in most States), did not measurably affect net gasoline consumption. Sales price increases, since they received no advance publicity, had no apparent effect at all.

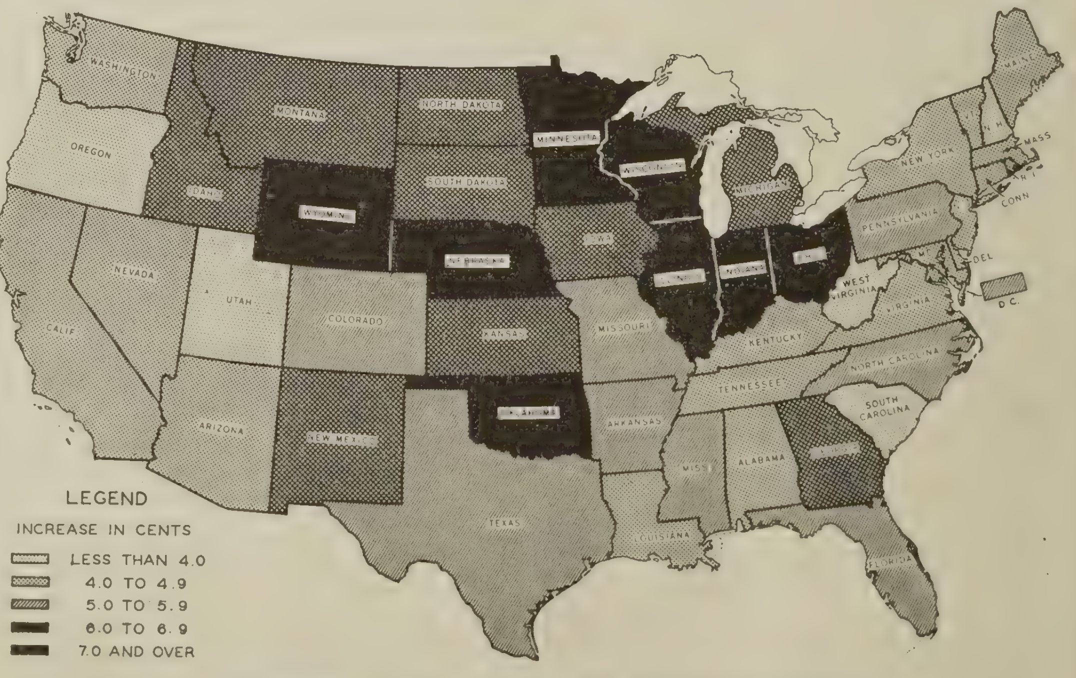
It is reasonably clear that at present price, wage, and employment levels, the demand for gasoline is so inflexible that no price or tax increases within reasonable contemplation will increase the total price to the consumer to the point where it will measurably affect the demand for highway gasoline.

From July 1, 1948, the close of the period covered by this study, to February 1, 1949, there were further net increases in the retail price of gasoline in 35 States, ranging from 0.1 to 1.5 cents; and two decreases of 0.1 and 0.2 cent. There were no increases in gasoline taxes.

THE FLEXIBILITY of the demand for gasoline is a problem that has long concerned highway economists and highway administrators. Stated in its simplest terms, the question is "do changes in the cost of gasoline to the consumer affect the quantity



INCREASES IN STATE GASOLINE TAX RATES



INCREASES IN GASOLINE PRICES EXCLUDING TAXES

Figure 1.—Increases in State gasoline tax rates and in gasoline sale prices excluding taxes, January 1, 1946–July 1, 1948.

of gasoline used on the highway?" The question is particularly important at this time. Many States have found that their current revenues from gasoline taxes—the revenues that, in large part, determine their ability to build and maintain an adequate highway system—are insufficient to construct and maintain highways to modern service and safety standards.

Since January 1, 1946, there have been 12 increases in State gasoline tax rates. There has also been one decrease—a temporary 2-cent tax in Oklahoma expired on January 1, 1947. The increases in State gasoline taxes are shown in table 1.

The purpose of this study was to determine, if possible, whether these changes in State gasoline-tax rates have affected the consumption of gasoline on the highways. The study is based entirely on the 30-month period from January 1946, through June 1948, and the discussion covers that period unless otherwise specified. The gasoline consumption and traffic comparisons made are all for the 1947–1946 and 1948–1947 relationships. Kansas and Virginia increased their tax rates from 3 to 4 cents and from 5 to 6 cents, respectively, in 1946, but since comparisons of relative changes in these two States would have necessitated use of 1945 data for periods in which gasoline rationing was still in effect, these two States were omitted from the study insofar as the effects of their 1946 gasoline-tax rate increases are concerned. The Louisiana tax rate increased from 7 to 9 cents per gallon on June 7, 1948, but sufficient data are not yet available to permit a full evaluation of the effects of that change. It is felt, however, that this study, based on the 1947 and 1948 changes in State tax rates, has a sufficiently broad base to justify its conclusions.

The principal difficulty encountered in this study was the fact that gasoline prices, excluding tax, increased rather sharply during the period under study, and in all cases the price increases were more than twice the amount of the increases in the tax rate.

In this article the word "price", unless otherwise noted, means the observed retail price of "regular" grade gasoline, excluding the State tax. These prices were obtained for the District of Columbia and for the capital city of each State, except in Maryland and Oregon, for which Baltimore and Portland prices were used. Since gasoline prices fall within a relatively narrow range in any area, it is felt that these prices are fairly representative. The gasoline consumption data used are from Public Roads analyses of motor-fuel consumption, which in turn are based on reports received from the State authorities. The traffic data were obtained from automatic traffic recorders located principally on rural roads in each State. Since the number of these recorders is limited, and comprehensive urban traffic information is not available, the data obtained from them for any one State must be considered as indicative rather than as an absolute measurement. The State-by-State traffic figures were, however, sufficiently uniform and consistent with the gasoline consumption data to warrant their use in the study. There is a probability that rural traffic in the period increased slightly more than urban traffic, but it does not appear that this could have been sufficient to make a significant difference in the findings.

Table 1.—*Increases in State gasoline taxes, January 1, 1946–July 1, 1948*

State	Tax rate			Effective date of change
	Old rate	New rate	Increase	
	Cents	*Cents*	*Cents*	
Kansas	3	4	1	Mar. 1, 1946
Virginia	5	6	1	June 19, 1946
Colorado	4	6	2	Apr. 1, 1947
Vermont	4	4.5	.5	May 1, 1947
Rhode Island	3	4	1	May 28, 1947
Maine	4	6	2	June 1, 1947
California	3	4.5	1.5	July 1, 1947
Connecticut	3	4	1	July 1, 1947
Maryland	4	5	1	July 1, 1947
Dist. of Columbia	3	4	1	Aug. 1, 1947
Kentucky	5	7	2	Apr. 1, 1948
Louisiana	7	9	2	June 7, 1948

PRICE RISES EXCEEDED TAX INCREASES

The January 1, 1946, price of regular gasoline and the State tax rates in effect on that date are given in table 2. This table shows the month-by-month changes in prices and taxes that took place between January 1, 1946, and July 1, 1948, and gives a summary of the cumulative amounts of those changes. The price increases in each case represent the increase in the reported price on the first day of the month over the reported price on the first day of the month preceding; thus, the increases shown for August are the amounts by which August 1 prices exceeded July 1 prices. The changes in tax rates are listed under the month in which they occurred, since the exact dates are known.

There were two gasoline-tax rate changes in 1946—Kansas and Virginia each increased their tax rates 1 cent. Between July 1 and September 1 of the same year the gasoline prices in 36 States were increased the same amount or more, and between December 1, 1947, and January 1, 1948, there was a substantial price increase in every State. The smallest of these increases was 0.9 cent and the largest was 2.5 cents. The latter increase occurred in Iowa, and it is worth noting that it was attended by nowhere near the publicity that had been accorded the increase of 1 cent in the State's tax rate that occurred in 1945. In addition to the Iowa price increase of 2.5 cents, there were price increases of 2 cents per gallon or more in 17 other States between November 1, 1947, and January 1, 1948. During the period in which most of the tax increases occurred—April 1 through July 1, 1947—there were relatively few increases in the price of gasoline. This, of course, had a tendency to silhouette the tax changes and they received a considerable amount of unfavorable publicity.

Figure 1 shows the increases in gasoline taxes and the price increases in the period under study. As may be seen in the upper map, there was no geographic concentration in the tax increases. It is worth mentioning, however, that beginning with Massachusetts, New York, and New Jersey, and continuing westward through the populous and highly developed North Central and Central States, the 3-cent and 4-cent taxes in that area remained lower than the rates generally in effect throughout other parts of the country. It is in this group of States that the greatest agitation for toll roads is found. The tremendous latent opposition to increases in the gasoline-tax rates in these States has probably contributed a great deal towards forcing the proponents of high-standard highways to turn to toll roads as the only alternative offering some chance of obtaining modern highways within a relatively short period of time. This rigidity in the gasoline-tax rates in the area is encouraging support for toll roads that would have approximately the same economic effect on the user as 15 to 19 cents per gallon gasoline-tax rates on certain types of traffic.

Although it can be observed from the upper map in figure 1 that there was no geographic significance to the increases in the State gasoline-tax rates, the lower map in the figure shows a remarkable concentration of the larger price increases beginning with the North Central States and continuing as far west as Idaho and southwest to New Mexico. In fact, the very large increases in the price of gasoline in many States exceeded, in total cost to the consumer, the combined price and tax increases in other States. In Oklahoma, where there was a decrease of 2 cents in the tax rate during the period, the price of gasoline increased 8 cents per gallon, resulting in a net increase in cost to the consumer of 6 cents per gallon.

PRICE RISES GREATER WHERE TAX WAS UNCHANGED

The difficulty of determining the effect of gasoline-tax increases was accentuated by the fact that the average price increases in the States in which there were also tax increases was 4.53 cents per gallon, whereas in the States where the tax remained the same throughout the period, the price of gasoline was increased an average of 5.61 cents per gallon. The more than 1-cent-per-gallon greater average increase in price in the States in which there were no tax increases imposed an additional burden on consumers that, in theory at least, would have the same restraining effect as the tax increases, thus making it difficult to determine the economic effects of tax increases. The greater price increases in the States that did not have tax increases might possibly have been explained by economic factors in fields not explored during the study. However, available data and facilities made impractical an effort to isolate such factors. Furthermore, it did not seem that additional investigation on this point would make a material contribution toward the objective of determining whether State gasoline-tax rates had affected highway gasoline consumption.

Figure 2 shows for each State the total price and tax changes in the 30-month period. There was one decrease in tax rate and there

Table 2.—*Gasoline price and tax changes by months, Jan. 1, 1946-July 1, 1948*

[*In cents*]

State	Price of gasoline excluding State tax Jan. 1, 1946 [1]	State gasoline tax Jan. 1, 1946	Changes during 1946																						Changes during 1947							
			February		March		April		May		June		July		August		September		October		November		December		January		February		March		April	
			Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax
Alabama	18.5	6.0																							0.5						1.5	
Arizona	17.5	5.0													1.0										0.5		0.5				0.8	
Arkansas	15.5	6.5													1.0																2.0	
California	16.5	3.0													1.0												0.5				0.8	
Colorado	16.0	4.0													0.5		0.5														1.1	2.0
Connecticut	16.0	3.0			−0.5				0.2		0.2		0.1		0.9										0.2						1.1	
Delaware	15.3	4.0											0.3		1.0						0.3		0.1								1.4	
Florida	16.0	7.0			−0.2								0.2				0.8								0.3						1.2	
Georgia	15.5	6.0													0.5		0.8												0.3		0.9	
Idaho	19.0	6.0													1.0												0.5				0.8	
Illinois	15.7	3.0													1.1		0.9										0.3				1.0	
Indiana	15.9	4.0	−0.3								0.3		1.1				0.5								0.3				0.7		0.5	
Iowa	14.9	4.0					−0.2						0.2				1.7				0.5								0.2		1.0	
Kansas	14.9	3.0				1.0											2.1														1.1	
Kentucky	17.5	5.0	−0.2								−1.3				1.0								0.3		0.1				0.3		0.8	
Louisiana	15.5	7.0													0.5								0.5				0.5		1.0			
Maine	15.5	4.0			−0.9				0.9						0.9		0.4								0.2						1.1	
Maryland	14.2	4.0			−0.3				0.3								1.0						0.3						0.3		1.0	
Massachusetts	14.7	3.0			−0.1				0.1						0.9		0.5								0.2						1.1	
Michigan	15.9	3.0	−0.3										0.3		1.1		0.5														1.0	
Minnesota	15.2	4.0	−0.1		−0.1		0.1		−0.2		0.3		0.2		−0.8		2.0		−0.1		0.1		0.3						0.3		0.5	
Mississippi	14.8	6.0	−0.2								0.3												1.1						0.4		0.8	
Missouri	15.7	2.0									0.5						0.5										0.4		0.5		1.0	
Montana	18.0	5.0													2.0				1.0										1.0		0.2	
Nebraska	13.5	5.0													1.4		0.1		1.0				0.6		−0.1		−1.0		0.5		1.0	
Nevada	19.0	4.0													1.0												1.0		0.8			
New Hampshire	17.2	4.0															1.0						0.3								1.0	
New Jersey	15.5	3.0													1.0								0.3								1.1	
New Mexico	17.0	5.0													1.0		0.5				0.5										1.5	
New York	15.0	4.0					0.2				0.1				1.0		0.2								0.2		0.4				0.7	
North Carolina	16.2	6.0					0.6		−1.2						0.5								0.9						1.0		1.0	
North Dakota	17.7	4.0	−0.3												1.6		0.5										0.1				1.0	
Ohio	14.0	4.0																									1.5				1.5	
Oklahoma	13.5	7.5					1.0				−1.0		−1.0		1.5		2.5									−2.0						
Oregon	16.5	5.0													1.0										−0.5		0.5				0.8	
Pennsylvania	14.7	4.0													0.3		1.5								0.8						1.1	
Rhode Island	14.8	3.0													0.9		−0.1						0.2		0.2						1.1	
South Carolina	17.8	6.0							0.3														0.5								0.8	
South Dakota	17.5	4.0															1.8										0.2		0.2		0.3	
Tennessee	16.0	7.0													0.5		0.5								0.5						1.1	
Texas	14.5	4.0													1.0														0.5		0.5	
Utah	19.5	4.0															1.0		−0.5												1.0	
Vermont	17.4	4.0							−0.1		0.2		0.1		1.0				−0.1				0.1		0.6						1.1	
Virginia	15.6	5.0												1.0			0.8												0.7		0.9	
Washington	16.5	5.0															1.0										0.5				0.8	
West Virginia	18.0	5.0	−0.4		−0.3										0.6								0.3						0.2		0.8	
Wisconsin	15.9	4.0							−0.3				0.3		1.3		0.8										0.5				1.0	
Wyoming	16.0	4.0													1.0								2.0									
Dist. of Columbia	14.5	3.0			−0.3										1.3										0.3				0.3		1.0	

[1] The observed retail price of regular gasoline, including Federal and local taxes but excluding State taxes.

Table 2.—*Gasoline price and tax changes by months, Jan. 1, 1946–July 1, 1948—Continued*

[*in cents*]

State	Changes during 1947, continued																Changes during 1948														Total for period Jan. 1, 1946–July 1, 1948	
	May		June		July		August		September		October		November		December		January		February		March		April		May		June		July			
	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax	Price	Tax
Alabama															1.0		1.0				0.5										4.5	
Arizona			−0.3												0.2		1.8												0.1		4.6	
Arkansas											0.5						1.5												0.2		5.2	
California			−0.3			1.5									0.1		1.8												0.3		4.2	1.5
Colorado	0.9												1.0		−0.6		1.9														5.3	2.0
Connecticut						1.0							0.3				1.5														4.0	1.0
Delaware											0.3				0.3		1.0														4.7	
Florida	0.2		0.5				0.5						0.5				1.0				0.5										5.5	
Georgia			0.5						0.5		−0.4		0.4		1.0		1.0				1.0										6.5	
Idaho	0.7		−0.3												0.5		1.8												1.1		6.1	
Illinois													1.1		0.5		2.0		0.3								0.2				7.4	
Indiana							0.4						1.3				1.5		0.6								0.1				7.0	
Iowa													0.2				2.5		0.5								0.1				6.7	
Kansas					0.4								0.3		0.1		2.1														6.1	1.0
Kentucky			0.5												1.0		1.0				0.5			2.0							4.0	2.0
Louisiana													0.5				1.5													2.0	4.5	2.0
Maine				2.0			0.2								0.3		0.9														4.0	2.0
Maryland					0.2	1.0							0.3		0.4		0.9		0.1				0.1		0.1		−0.1		0.1		4.7	1.0
Massachusetts							0.5								0.3		1.4														4.9	
Michigan	0.5								0.7		0.1		1.1		0.1		1.5				0.1						0.1				6.8	
Minnesota	0.2		−0.2		−0.8		2.3		−0.8		0.3		1.2		1.1		2.0		0.3												8.1	
Mississippi	0.5		0.1				0.1				1.2		−2.0		0.6		2.0				0.4						0.1				5.4	
Missouri													1.1				1.5		0.2								0.2				5.9	
Montana													0.9				1.4		0.1												6.6	
Nebraska	0.5				0.7				0.1				0.7				2.0		−0.3												7.2	
Nevada			−0.3												0.3		1.8												0.3		4.9	
New Hampshire							0.1								0.3		0.9														3.6	
New Jersey											−0.3		0.3		0.6		1.0														4.0	
New Mexico													1.5				1.7												−0.2		6.5	
New York							0.3										1.4														4.5	
North Carolina																	2.2														5.0	
North Dakota									0.5				1.2		0.1		1.6		0.1								0.3				6.7	
Ohio					1.0								1.0				1.5												1.0		7.5	
Oklahoma	1.0												1.0				2.0										0.5				7.5	−2.0
Oregon			−0.3												0.2		1.8														3.5	
Pennsylvania															0.6		1.0														5.3	
Rhode Island			0.2	1.0			0.7								0.4		1.0										−0.2		0.2		4.6	1.0
South Carolina	0.1								0.5		−0.5		0.5				1.2														3.4	
South Dakota	0.5												1.8				0.9		0.2								0.1				6.0	
Tennessee									0.9						−0.3		1.3														4.5	
Texas			0.5				0.5								0.5		1.5														5.0	
Utah	1.0																1.0														3.5	
Vermont		0.5			0.8								0.4				0.9														4.8	0.5
Virginia													0.5				1.2														4.1	1.0
Washington			−0.3												1.1		1.8														4.9	
West Virginia									0.5				0.3				1.4														3.4	
Wisconsin													1.5				2.0		0.5								0.1				7.7	
Wyoming	1.5				1.0								1.0				1.5														8.0	
Dist. of Columbia					1.0			1.0					0.3				1.0		0.3												5.2	1.0

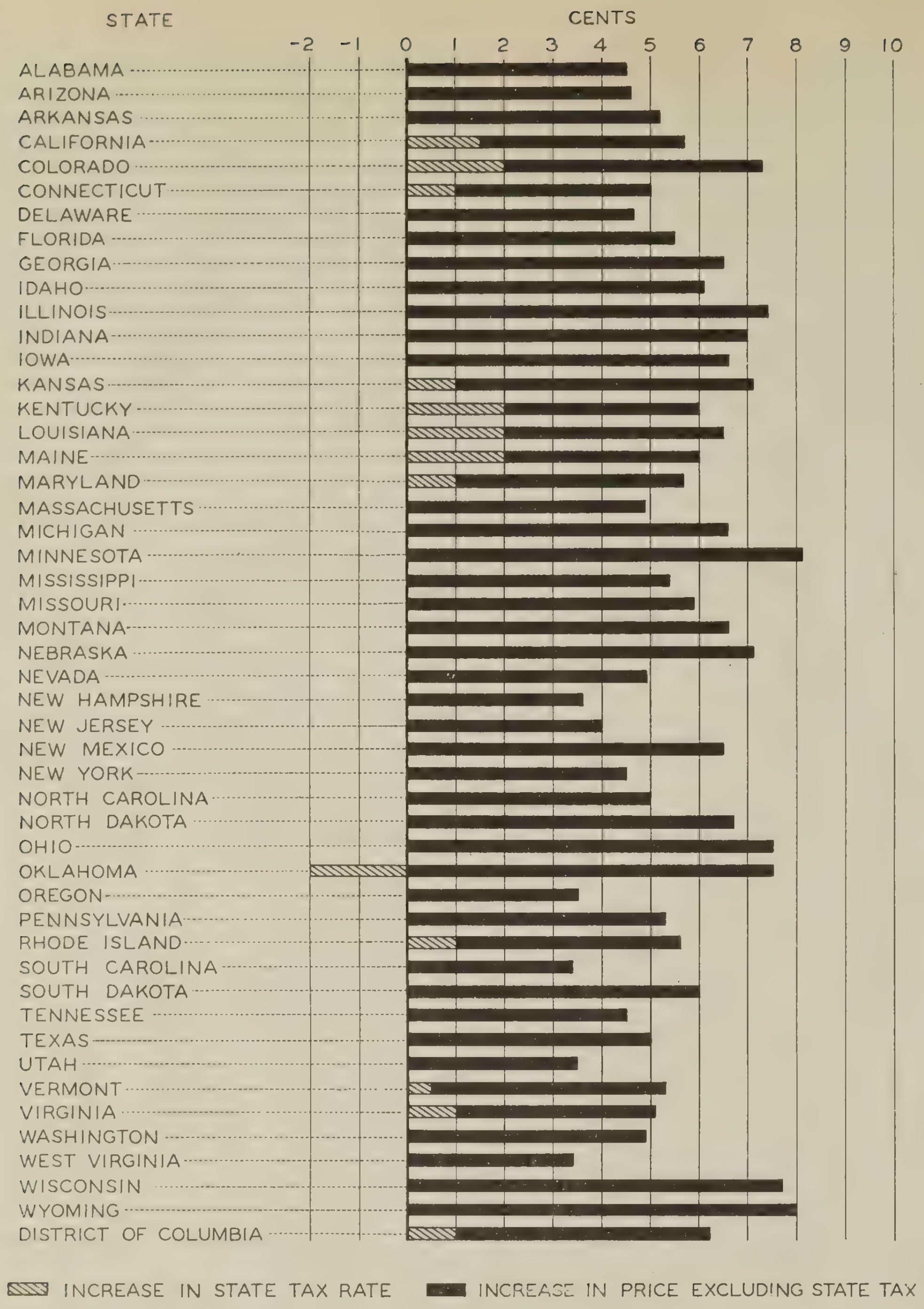


Figure 2.—Gasoline price and tax increases, January 1, 1946–July 1, 1948.

were no decreases in price. The increases in tax rates ranged from 0.5 cent per gallon in Vermont to 2 cents per gallon in Colorado, Kentucky, Louisiana, and Maine; and the increases in price ranged from 3.4 cents per gallon in South Carolina and West Virginia to 8.1 cents per gallon in Minnesota.

Table 3 shows the relative changes in sales of gasoline for use on highways, and the changes in traffic, for the 2 months prior to the month in which the change in tax rate took place, the month in which the tax rate took effect, and the following 2 months. The figures given show the changes, in percent, of 1947 sales and traffic compared to the same months of 1946 in all cases except for Kentucky and Louisiana. The latter two States increased their taxes in 1948, and the comparisons are therefore of 1948 data to those for 1947. Louisiana is omitted from table 3 because the tax change there was so recent that sufficient data were not available at the time the study was made. The Rhode Island tax increase from 3 to 4 cents took effect May 28, and for practical purposes was treated in this study as if it had taken place in June.

Within each group in table 3, the State in which the tax increase occurred is listed first, followed by adjoining States in which there were no changes in tax rates. One exception to this is the inclusion of Vermont for comparison with Maine. There was a half-cent-per-gallon increase in the Vermont tax on May 1, 1947, but it was felt that this increase did not destroy the validity of the comparison since the Maine tax increase a month later was 2 cents per gallon. It was not expected that the half-cent increase in the Vermont tax would be reflected in gasoline sales, and the State therefore was not set out in a separate grouping; but the table does show a very noticeable fluctuation in Vermont highway gasoline sales.

PUBLICITY ON TAX INCREASES INDUCES "LOADING UP"

Although any economic effects of gasoline-tax increases, as well as price increases, must be continuing, it seemed a reasonable assumption at the time the study was undertaken that the impact of a tax increase, reflected in the increased cost to the consumer, would be distinguishable in the demand for gasoline at the time the tax was imposed. This seemed especially likely because of the very great publicity given to the tax increases. The significance of table 3 therefore lies more in the month-by-month figures than in the totals for the 5-month periods bracketing the tax increases. A very noticeable "loading up" can be observed in the months prior to the tax increases, coupled with a reduction in inventories in the month of change and the succeeding month. Rhode Island appears to be an exception, but this probably was the result of a combination of factors: Gasoline sales in the same month of the prior year were abnormally low; Rhode Island is a small State whose highways carry a relatively high proportion of interstate traffic; and the tax rate before the increase was only 3 cents. Furthermore, it should be noted that Rhode Island traffic in the month in which the change took place was up 17.4 percent over the same month of the prior year, and in the month following was up more than 40 percent; but it is also possible that the traffic-recorder data in this instance did not accurately reflect actual changes in traffic.

The gasoline tax is imposed on the "first sale" in most States. Consequently, the taxed sales given in table 3 reflect any changes in distributors', retailers', and consumers' inventories and do not necessarily reflect the month of the use of gasoline on the highways by the ultimate consumer. (The gasoline consumption data in table 4, however, have been adjusted to the month of consumption, and in this respect differ from those in table 3.)

In most States the tax on gasoline applies to distributors' in-shipments, and in the remaining States to distributors' sales. The dates of tax increases are known in advance and there appears to be a strong tendency to utilize all storage capacity immediately prior to the tax increases. Although tax increases are frequently accompanied by "floor taxes," imposing the additional tax on inventories, these increased inventories reveal, to a degree, the hope of somehow avoiding the tax. Undoubtedly this "loading up" takes place throughout the supply channels, including retail outlets, and probably includes a considerable amount of gasoline sold to consumers who purchase in bulk. In Maine, for instance, the May 1947, sales of gasoline for highway use exceeded those of May 1946, by 28.3 percent, but gasoline sold in June, the month of the tax change, was 11.5 percent less than in the same month of 1946. Traffic, on the other hand, was 8 percent greater in May 1947, and 9.8 percent greater in June. The 9.8 percent increase in June 1947, over June 1946, was, as a matter of fact, greater than in the adjoining States of New Hamp-

Table 3.—*Percentage changes in highway gasoline sales and traffic in year of tax increase from same months of prior year*

Month in which tax was increased	State	Second preceding month		Preceding month		Month of change		Following month		Second following month		Total, 5 months	
		Highway gasoline sales	Traffic	Highway gasoline sales	Traffic	Highway gasoline sales	Traffic	Highway gasoline sales	Traffic	Highway gasoline sales	Traffic	Highway gasoline sales	Traffic
Apr. 1947	COLORADO	+14.7	+0.5	+19.1	+6.4	−2.9	+5.9	+3.3	+8.5	+7.9	+12.3	+8.1	+7.0
	Oklahoma	+12.9	+2.0	+11.5	+2.2	+2.1	+6.8	+9.1	+2.9	+11.5	+7.5	+9.3	+4.4
	Utah	+15.9	+5.6	+15.1	+11.1	+4.2	+6.7	−0.8	+13.5	+9.9	+10.8	+8.2	+9.8
	Wyoming	+19.6	+4.0	+21.9	+13.6	+7.5	+5.5	+8.6	+9.2	+19.2	+12.5	+14.8	+9.2
	Group total	+14.3	+2.0	+15.2	+5.2	+1.4	+6.4	+5.7	+6.1	+10.9	+9.7	+9.2	+6.1
	U. S. total	+11.6	+8.8	+7.1	+6.0	+3.5	+9.7	+12.5	+10.6	+13.8	+11.3	+9.7	+9.4
June 1947	MAINE	+10.3	+5.3	+28.3	+8.0	−11.5	+9.8	+4.5	+9.7	+7.9	+13.0	+7.6	+9.4
	New Hampshire	+1.0	+6.3	+8.0	+10.8	+10.4	+5.0	+8.8	+12.0	+11.4	+15.1	+8.4	+10.4
	Vermont	+14.4	+7.6	−3.1	+10.4	+12.2	+7.1	+6.7	+6.2	+8.6	+12.9	+7.5	+8.9
	Group total	+8.5	+6.1	+16.0	+9.2	−0.5	+8.0	+6.2	+9.4	+9.1	+13.5	+7.8	+9.5
	RHODE ISLAND	+2.9	+7.2	+4.4	+16.4	+12.0	+17.4	+12.5	+40.7	+8.7	+26.1	+8.2	+22.6
	Massachusetts	+5.5	+8.9	+6.9	+11.6	+9.8	+6.8	+4.1	+7.5	+12.6	+13.8	+7.8	+9.8
	New Jersey	+5.5	+14.8	+7.8	+10.4	+12.3	+8.0	+2.1	+11.0	+8.0	+13.2	+7.1	+11.1
	New York	+1.9	+8.5	+7.7	+8.2	+8.9	+14.1	+10.8	+22.0	+8.2	+9.0	+7.7	+12.7
	Group total	+3.5	+9.8	+7.4	+9.5	+10.0	+11.7	+7.4	+18.2	+9.0	+11.1	+7.6	+12.3
	U. S. total	+3.5	+9.7	+12.5	+10.6	+13.8	+11.3	+7.4	+11.7	+8.0	+10.9	+9.0	+10.9
July 1947	CALIFORNIA	+3.1	+8.0	+18.1	+6.1	+1.2	+4.5	+11.4	+5.3	+17.3	−2.2	+10.1	+4.1
	Nevada	+5.6	+6.1	+13.8	+10.2	+14.1	+11.3	+6.6	+12.3	+7.8	+12.5	+9.6	+10.6
	Oregon	+14.7	+9.1	+11.1	+14.1	+15.8	+17.5	+7.5	+19.6	+10.4	+12.9	+11.8	+14.8
	Washington	+6.3	+4.6	+10.5	+7.1	+9.1	+2.2	+4.7	+6.5	+7.4	+4.7	+7.5	+5.0
	Group total	+4.9	+7.5	+16.1	+7.4	+4.2	+6.0	+9.8	+7.5	+14.9	+1.2	+9.9	+5.9
	CONNECTICUT	+10.5	+11.1	+21.8	+13.1	−0.3	+15.6	+6.7	+16.3	+12.1	+12.1	+9.9	+13.8
	Massachusetts	+6.9	+11.6	+9.8	+6.8	+4.1	+7.5	+12.6	+13.8	+8.0	+8.1	+8.2	+9.5
	New Jersey	+7.8	+10.4	+12.3	+8.0	+2.1	+11.0	+8.0	+13.2	+21.1	+9.1	+9.8	+10.3
	New York	+7.7	+8.2	+8.9	+14.1	+10.8	+22.0	+8.2	+9.0	+16.4	+5.8	+10.3	+11.8
	Group total	+7.8	+9.4	+11.1	+11.7	+6.5	+17.3	+8.8	+11.1	+15.3	+7.2	+9.8	+11.3
	MARYLAND	+16.2	+10.8	+19.6	+11.3	+1.2	+8.4	+3.7	+8.4	+7.8	+3.0	+9.4	+8.3
	Delaware	+7.3	+19.3	+8.1	+22.2	+6.7	+18.8	+2.4	+17.3	+9.1	+5.4	+6.6	+16.9
	Pennsylvania	+8.3	+8.7	+12.4	+10.8	+4.8	+12.1	+7.2	+12.1	+13.4	+10.4	+9.0	+10.9
	Virginia	+13.4	+10.7	+10.7	+13.9	+11.2	+13.9	+0.5	+14.5	+12.4	+7.7	+9.4	+12.1
	Group total	+10.3	+10.3	+12.9	+12.5	+5.7	+12.3	+5.2	+12.4	+12.3	+8.1	+9.1	+11.1
	U. S. total	+12.5	+10.6	+13.8	+11.3	+7.4	+11.7	+8.0	+10.9	+13.7	+8.3	+11.0	+10.6
Aug. 1947	DIST. OF COLUMBIA	+10.4	+5.3	+16.3	+9.3	+5.4	+4.2	+11.7	+3.9	+6.6	+18.4	+10.0	+6.0
	Delaware	+8.1	+22.2	+6.7	+18.8	+2.4	+17.3	+9.1	+5.4	+9.5	+11.3	+7.0	+15.5
	Pennsylvania	+12.4	+10.8	+4.8	+12.1	+7.2	+12.1	+13.4	+10.4	+13.0	+15.0	+10.0	+12.2
	Virginia	+10.7	+13.9	+11.2	+13.9	+0.5	+14.5	+12.4	+7.7	+28.0	+10.2	+11.9	+12.1
	Group total	+11.7	+11.2	+6.9	+12.7	+5.4	+12.4	+13.0	+8.4	+15.5	+13.1	+10.3	+11.6
	U. S. total	+13.8	+11.3	+7.4	+11.7	+8.0	+10.9	+13.7	+8.3	+11.1	+8.9	+10.7	+10.2
Apr. 1948	KENTUCKY	+0.1	+21.1	+44.0	+38.5	−5.5	+21.1	+11.6	+21.4	+12.3	+20.7	+12.4	+24.3
	Ohio	+20.7	+12.6	+12.3	+14.9	+11.7	−0.4	+17.1	+5.2	+5.0	+10.7	+12.8	+8.2
	Tennessee	+1.1	+7.5	+7.6	+16.7	+11.1	+14.9	+24.6	+11.8	−4.3	+13.6	+8.1	+12.9
	West Virginia	+13.4	+14.0	+27.4	+23.6	+24.2	+7.4	+24.9	−1.5	+9.0	+10.7	+19.4	+9.8
	Group total	+13.3	+13.4	+17.6	+20.7	+10.2	+7.0	+18.3	+8.3	+4.9	+12.9	+12.5	+12.2
	U. S. total	+6.2	+5.5	+10.9	+7.9	+10.6	+7.9	+5.0	+8.4	(1)	+7.1	(1)	+7.4

[1] Data not available at time this table was prepared.

shire and Vermont, where increases of 5.0 percent and 7.1 percent, respectively, were experienced. In Connecticut, gasoline sold for highway use in June 1947, exceeded that for June 1946, by 21.8 percent, but in July it was 0.3 percent less than that for July of the previous year. For the 5-month period Connecticut highway gasoline sold showed a 9.9 percent increase in 1947 over the same months of 1946, slightly greater than the average for the adjoining States—Massachusetts, New York, and New Jersey.

The immediate effect of this "loading up" is to give the appearance, in the month of the tax increase and immediately following while inventories are being reduced to normal, that gasoline consumption has suffered substantially as a result of the impact of the tax increase. A close analysis of gasoline consumption, however, reveals that the 5-month totals for the States in which the increases occurred are very similar to those of the adjoining States in which there were no increases. As inventories in the supply channels are brought back to normal it frequently appears, to those not thoroughly familiar with the distribution and taxation of gasoline, that the demand for gasoline has been decreased by the increase in tax. This misinterpretation has frequently accounted for articles appearing in newspapers and trade journals to the effect that gasoline demand has been sharply cut by tax increases. Recent instances of such misinterpretation occurred with respect to Vermont and Kentucky gasoline consumption. In both cases abnormally large amounts of gasoline had been purchased immediately prior to the imposition of the tax increase, but the total amount sold in the 5-month period bracketing the increases showed no marked deviation between the sales patterns of those States and those of adjoining States.

TRAFFIC UNAFFECTED BY TAX INCREASES

Table 3 also demonstrates that in each of the States in which the tax increases occurred the traffic maintained fairly normal patterns similar to those of adjoining States, and, allowing for regional differences, consistent with the pattern of total traffic in the United States. It will be noted that in each of the States in which tax changes occurred, traffic remained on a fairly even keel, in each case being similar in pattern to the traffic of adjoining States. This appears to be conclusive evidence that the impact of the tax increases, while resulting in a violent fluctuation in gasoline sold, does not substantially affect the use of gasoline on the highways.

Theoretically, each increase in the cost of gasoline, whether arising from taxes or other factors, should reduce the potential market; and each decrease in the cost should expand the potential market. In a period of relatively stable prices and employment it might have been possible to distinguish the effects of the changes in gasoline-tax rates, or conversely to decide with a reasonable degree of certainty that the changes had no appreciable effect on consumption. The fact that there were 12 increases in tax rates and 1 decrease during the period under study would in normal times have created, as nearly as it is possible to create, a laboratory condition. It might have been possible to have settled once and for all the question of the extent to which the demand for gasoline for highway use is flexible, and perhaps to have made a determination of its sensitivity. From the point of view of making this determination, it is unfortunate that the tax increases were, to a considerable degree, the result of a general rise in all price levels that at the same time rendered comparisons difficult.

There can be no doubt that at some point the cost of highway transportation will govern the amount of gasoline used, and, for that matter, the distribution and ownership of motor vehicles; but it appears that we have not yet arrived at the point where these costs are sufficient to constitute an effectual brake on the use of highway transportation. Consumption of gasoline under present conditions of full employment and high wages is more likely to be determined by the number of vehicles available and the facilities for their use than by the price of gasoline. Gasoline and oil costs, which account for the principal day-to-day expense of operating an automobile, amount to approximately 1.8 cents per mile. If we take, for example, a new automobile costing the consumer $1,800 and assume that it is to be depreciated over 100,000 miles, the depreciation alone is 1.8 cents per mile, equaling the cost of gasoline and oil, and allowing nothing for maintenance, garaging, insurance, registration fees, and property taxes.

It is quite possible that the economic effects of high motor-vehicle transportation costs will be revealed much sooner in the market for automobiles than in the market for gasoline. Even allowing for the fact that the average consumer may buy, or refrain from buying, gasoline at any given time and that the demand for gasoline, therefore, must be much more sensitive than the demand for cars, and the fact that the automobile market must, of necessity, have much less short-term sensitivity, it seems probable that any change in the long-term curve of gasoline demand will be preceded by a very substantial weakening in the market for automobiles. In other words, it does not appear that the need for highway transportation has been satisfied to the point that gasoline price increases or tax increases, within reasonable limits, will have any effect on the amount of gasoline consumed.

GASOLINE COST INCREASE LESS THAN INCREASE IN GENERAL LIVING COST

On January 1, 1946, the unweighted arithmetic average retail price of gasoline for the United States was 20.6 cents per gallon. At the end of the 30-month period under study the same average price had risen to 26.3 cents, an increase of 27 percent. In the same period the Bureau of Labor Statistics' Cost of Living Index, based on the 1935–39 period, rose from 129.9 in January 1946, to 173.7 in July 1948, an increase of more than 33 percent. Thus, despite the fact that the total cost of gasoline to the consumer rose rapidly during the period, its relative increase was not as great as the increase in his general cost of living. Between January 1946, and July 1948, hourly earnings in manufacturing industries increased from an average of just over $1.00 an hour to more than $1.30 per hour. Agricultural incomes increased even more rapidly, and there were substantial increases in other industries, coupled with full employment. During this period the relative cost of gasoline, including taxes, actually decreased for all groups except those depending on fixed annual salaries, annuities, rents, and other relatively stable sources of income. It was with these facts in mind that this inquiry was limited to an effort to determine whether the increases in State gasoline taxes had affected gasoline consumption, rather than an attempt to learn under what conditions gasoline consumption would have been affected.

Table 4.—*Highway use of motor fuel, 1946–47, in States that did and did not have tax increases*

Month	States in which tax rate increased during 1947			States in which tax rate did not increase during 1947			Total, all States		
	1946	1947	Change	1946	1947	Change	1946	1947	Change
	1,000 gallons	*1,000 gallons*	*Percent*	*1,000 gallons*	*1,000 gallons*	*Percent*	*1,000 gallons*	*1,000 gallons*	*Percent*
January	271,130	327,986	+21.0	1,483,602	1,695,510	+14.3	1,754,732	2,023,496	+15.3
February	266,803	312,988	+17.3	1,421,094	1,571,311	+10.6	1,687,897	1,884,299	+11.6
March	311,059	320,428	+3.0	1,691,364	1,824,031	+7.8	2,002,423	2,144,459	+7.1
April	320,213	343,085	+7.1	1,888,298	1,943,300	+2.9	2,208,511	2,286,385	+3.5
May	344,709	366,271	+6.3	1,894,852	2,153,106	+13.6	2,239,561	2,519,377	+12.5
June	340,949	395,062	+15.9	1,859,000	2,108,651	+13.4	2,199,949	2,503,713	+13.8
First 6 months	1,854,863	2,065,820	+11.4	10,238,210	11,295,909	+10.3	12,093,073	13,361,729	+10.5
July	371,860	382,945	+3.0	2,061,328	2,230,541	+8.2	2,433,188	2,613,486	+7.4
August	371,261	404,741	+9.0	1,999,159	2,155,644	+7.8	2,370,420	2,560,385	+8.0
September	336,380	386,444	+14.9	1,818,374	2,062,616	+13.4	2,154,754	2,449,060	+13.7
October	346,408	388,972	+12.3	1,948,165	2,159,481	+10.8	2,294,573	2,548,453	+11.1
November	322,489	368,921	+14.4	1,839,408	1,882,730	+2.4	2,161,897	2,251,651	+4.2
December	326,750	396,911	+21.5	1,814,343	2,034,030	+12.1	2,141,093	2,430,941	+13.5
Last 6 months	2,075,148	2,328,934	+12.2	11,480,777	12,525,042	+9.1	13,555,925	14,853,976	+9.6
Total	3,930,011	4,394,754	+11.8	21,718,987	23,820,951	+9.7	25,648,998	28,215,705	+10.0

A summary of highway gasoline consumption is given in table 4. The 1946–47 changes are given in totals for the group of States in which there was a tax-rate increase in 1947, and in totals for the group of States in which the rate did not increase during 1947. These summaries show that in the first 6 months of 1947 the States in which the taxes were increased during the year had an increase of 11.4 percent in highway gasoline sales; and in the last 6 months of 1947 showed an even greater increase of 12.2 percent over the prior year. This is surprising, since most of the tax changes took place about the middle of the year, with most of the "loading up" of inventories taking place during the first 6 months, and the unloading during the last 6 months. Had it not been for the loading effect, the last-half increase in 1947 over the same period in 1946 would have been greater. Strangely enough, the States in which there were no increases in tax rates during 1947 showed an increase of 10.3 percent in highway gasoline consumption in the first 6 months of the year over the same months of 1946, and a smaller increase, 9.1 percent, in the last 6 months of the year. It is not possible to arrive at a conclusive explanation for this apparent defiance of economic law, if we consider the changes in tax rates alone. We do know, however, that the average price of gasoline, without tax, increased more in the States that did not increase the tax rate than it did in the States where the tax rates were increased, and for longer periods this undoubtedly nullified the relative effects of the tax increases.

CONCLUSIONS

It would be irresponsible to conclude from the data compiled that increased costs to the consumer would not, in the long run, have a tendency to reduce the consumption of gasoline. It is apparent, however, that we have not yet reached the point where this effect can be measured. At the time the study was undertaken it was hoped the effects of gasoline-tax increases could be measured, despite the fact that the price increases so overshadowed them. It was felt that the impact of the tax increases, considering the publicity given them, could be located and measured; but this expectation was not realized.

It is reasonably clear that at present price, wage, and employment levels, the demand for gasoline is so inflexible that no price or tax increases within reasonable contemplation will increase the total price to the consumer to the point where it will measurably affect the demand for highway gasoline.

New Publications

Work of the Public Roads Administration, 1948, the annual report of the Public Roads Administration for the fiscal year ended June 30, 1948, is now available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 20 cents a copy.

Highway Statistics, 1947, is also now available. The third in an annual series, it presents information of general interest on the subjects of motor fuel, motor vehicles, highway-user taxation, highway finance, and highway mileage for the year 1947. A summary bulletin reporting similar information over periods of 20 to 50 years, up to 1945, was printed last year. These publications are for sale by the Superintendent of Documents at the following prices:

Highway Statistics, 1947, 45 cents.
Highway Statistics, 1946, 50 cents.
Highway Statistics, 1945, 35 cents.
Highway Statistics, Summary to 1945, 40 cents.

Traffic Trends on Rural Roads in 1947

*BY THE DIVISION OF HIGHWAY TRANSPORT RESEARCH
PUBLIC ROADS ADMINISTRATION*

Reported by THOMAS B. DIMMICK, Highway Economist

Total rural-road traffic in 1947 broke all previous records, exceeding the previous high in 1946 by almost 10 percent. Peak summer travel was 7 percent greater than in 1941, previous record year for that season.

Travel on the main rural roads of the country amounted to more than 137 billion vehicle-miles, of which almost 80 percent was by passenger cars. Ton-mileage carried by commercial vehicles increased 21 percent for the second consecutive year. Reversing a previous trend, a slightly larger percentage of these vehicles were found to be carrying loads in 1947. Average carried loads remained about the same as in 1946.

The use of heavy commercial vehicles continued to increase, truck-combination travel being 21 percent greater than in 1946. The rise in frequency of heavy gross weights has apparently been halted, but the frequency of heavy axle loads was almost one-fifth greater in 1947 than in the previous year.

TRAFFIC on rural roads in 1947 broke all records, exceeding the all-time high of the previous year by almost 10 percent. Travel in each month of 1947 was greater than in the corresponding month of 1946, the increases ranging from 6 percent in March, November, and December to 13 percent in January. The peak summer travel was about 7 percent above that for 1941, the year of the previous all-time high for that season.

On the 345,000 miles of main rural roads of the country, travel in 1947 was more than 137 billion vehicle-miles, of which almost 21 percent was by trucks and truck combinations.[1] Vehicle-mileage of these commercial vehicles in 1947 increased to 18 percent above the 1946 figure and ton-mileage, 21 percent. The increased use of truck combinations, particularly noticeable during the war, was continued through 1947. The percentage of vehicles carrying loads increased slightly.

The total rural-road traffic data reported in this analysis are derived largely from records received from about 660 automatic traffic recorders operated continuously throughout the year at permanent stations on rural roads in all 48 States. These machine counts provide no classification by vehicle type since they record only the total number of all types passing. Trends in type, weight, and characteristics of trucks and truck combinations were obtained from a summer survey described later in this article. Supplemental counts made by several States yielded valuable information concerning the total volume of rural traffic within their boundaries and its classification by types of vehicles. Consideration has been given to all such available data, and those derived from the sample with the most complete coverage were given preference in this analysis. In instances where States have prepared and submitted vehicle-mile travel estimates, these have been employed rather than estimates made by applying trend factors.

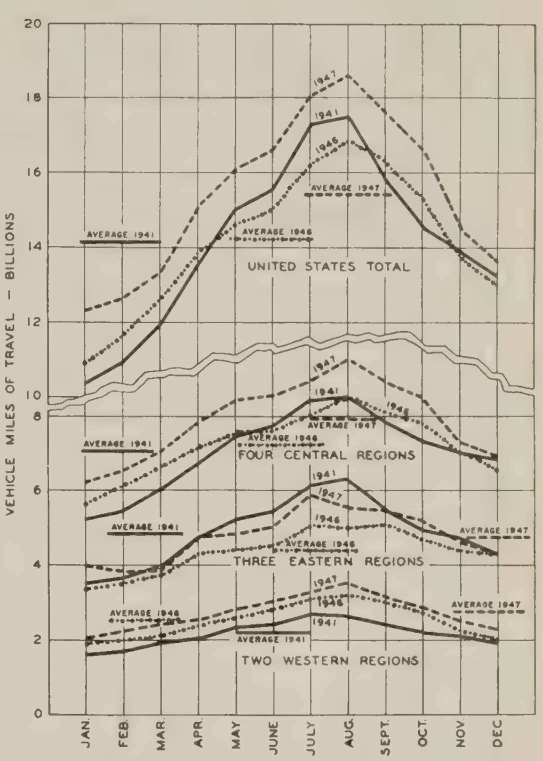


Figure 1.—Travel on all rural roads in 1941, 1946, and 1947, by months.

Figure 1 illustrates the variation in rural traffic in the three main geographic divisions and in the United States as a whole in the year 1947; in the previous year, 1946; and in the peak prewar year, 1941. In the three eastern regions, 1947 traffic was less than that in 1941 throughout most of the year; whereas in the other regions the 1947 traffic in each month was well above that of the corresponding month of any previous year. The States comprising each of these regions, which have been established by the Bureau of the Census, are indicated in the first column of table 3, page 147.

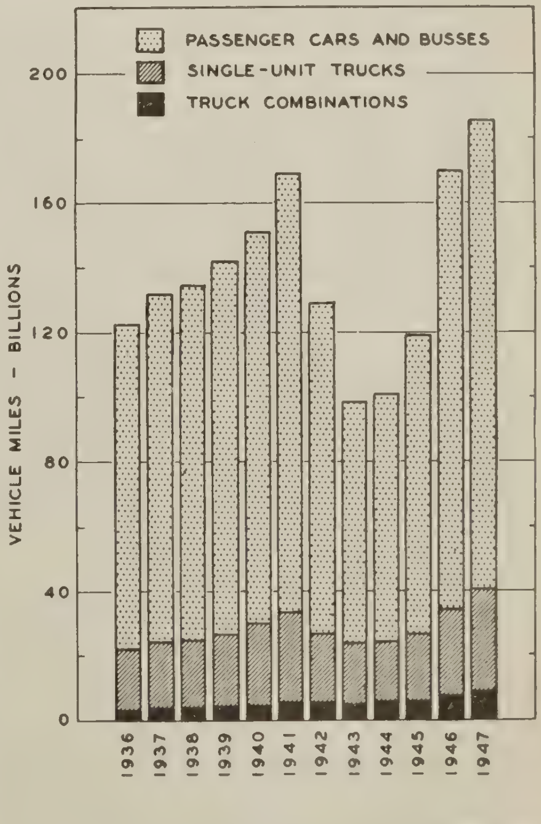


Figure 2.—Travel on all rural roads, 1936–47, by classes of vehicles.

Vehicle-mileage of travel on all rural roads, by type of vehicle, is shown in chart form for each year from 1936 to 1947, inclusive, in figure 2. Evident from this chart is the stability of the truck traffic. Even during the war period it decreased less than 26 percent from the prewar high, while passenger-car traffic decreased over 45 percent. Truck traffic, as well as passenger-car traffic, has regained all of the wartime loss and now stands about where indicated by the prewar trend. Travel by truck combinations during the years of the war was even more stable, and maintained throughout that period approximately the same level as in 1941. Since the end of the war period, the vehicle-mileage of truck combinations has increased annually at a rapid rate.

The ratios of rural traffic volumes in 1947 to those in corresponding months of 1946 and 1941 are shown in table 1. The uniform increases in traffic in 1947 compared to 1946, in all sections of the country, are clearly shown. With the exception of the Middle Atlantic region (in March and in December) the traffic in every region for every month was equal to, or greater than, that in the same period of the previous year. On the other hand, the com-

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[1] In this article, the term *trucks* is used to indicate single-unit trucks; *truck combinations* to indicate tractor-truck-semitrailers (with or without full trailers) and trucks with full trailers; and *trucks and truck combinations* to indicate all of these vehicles together.

Table 1.—*Ratio of traffic volume on rural roads in 1947 to that in corresponding months of 1946 and 1941, as determined from automatic traffic recorder data*

Region	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
RATIO OF 1947 TRAFFIC TO 1946 TRAFFIC													
Eastern regions:													
New England	1.18	1.19	1.07	1.08	1.11	1.09	1.12	1.15	1.09	1.12	1.07	1.01	1.10
Middle Atlantic	1.17	1.11	.97	1.10	1.09	1.12	1.17	1.11	1.08	1.12	1.06	.98	1.09
South Atlantic	1.21	1.10	1.07	1.15	1.13	1.14	1.15	1.14	1.10	1.12	1.08	1.07	1.12
Average	1.19	1.11	1.04	1.12	1.11	1.12	1.15	1.13	1.09	1.12	1.07	1.03	1.11
Central regions:													
East North Central	1.21	1.10	1.09	1.12	1.14	1.15	1.13	1.12	1.11	1.11	1.03	1.03	1.11
East South Central	1.04	1.03	1.05	1.10	1.11	1.12	1.11	1.09	1.06	1.09	1.08	1.10	1.08
West North Central	1.16	1.09	1.06	1.07	1.11	1.12	1.12	1.14	1.12	1.10	1.02	1.04	1.10
West South Central	1.00	1.02	1.02	1.06	1.05	1.07	1.06	1.06	1.05	1.04	1.06	1.06	1.05
Average	1.12	1.06	1.06	1.09	1.11	1.12	1.11	1.11	1.09	1.09	1.04	1.05	1.09
Western regions:													
Mountain	1.09	1.07	1.11	1.08	1.11	1.11	1.11	1.12	1.14	1.14	1.08	1.11	1.11
Pacific	1.09	1.13	1.10	1.08	1.08	1.07	1.06	1.07	1.01	1.00	1.11	1.13	1.07
Average	1.09	1.11	1.10	1.08	1.09	1.08	1.08	1.09	1.05	1.04	1.10	1.12	1.08
United States average	1.13	1.09	1.06	1.10	1.11	1.11	1.12	1.11	1.08	1.09	1.06	1.06	1.09
RATIO OF 1947 TRAFFIC TO 1941 TRAFFIC													
Eastern regions:													
New England	1.07	.99	1.05	.91	.86	.83	.83	.81	.95	.97	.83	.81	.89
Middle Atlantic	1.08	1.07	.82	.96	.86	.87	.95	.83	1.00	1.04	.96	1.04	.95
South Atlantic	1.18	1.11	1.13	1.10	1.08	1.08	1.04	1.02	1.06	1.14	1.09	1.08	1.09
Average	1.13	1.08	.99	1.01	.94	.95	.96	.90	1.02	1.07	.99	1.02	.99
Central regions:													
East North Central	1.30	1.24	1.22	1.17	1.12	1.06	.98	1.07	1.10	1.14	.93	.90	1.09
East South Central	1.11	1.17	1.18	1.16	1.14	1.09	1.04	1.19	1.13	1.18	1.22	1.16	1.14
West North Central	1.15	1.06	1.05	1.05	1.02	1.07	1.05	1.08	1.13	1.13	1.00	.98	1.06
West South Central	1.17	1.24	1.22	1.27	1.28	1.22	1.24	1.23	1.20	1.26	1.22	1.15	1.22
Average	1.21	1.19	1.18	1.17	1.13	1.10	1.06	1.12	1.13	1.17	1.05	1.01	1.12
Western regions:													
Mountain	1.21	1.19	1.11	1.16	1.12	1.17	1.13	1.21	1.26	1.23	1.07	1.21	1.17
Pacific	1.31	1.31	1.31	1.28	1.23	1.34	1.30	1.37	1.33	1.33	1.24	1.21	1.30
Average	1.28	1.27	1.24	1.24	1.19	1.28	1.24	1.31	1.31	1.30	1.18	1.21	1.25
United States average	1.19	1.16	1.12	1.12	1.08	1.07	1.05	1.07	1.12	1.15	1.05	1.04	1.10

Table 2.—*Percentage of annual traffic in each month in 1947*

Region	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Eastern regions:													
New England	5.8	6.2	7.1	7.9	8.7	8.8	10.5	10.6	10.4	9.8	7.7	6.5	100.0
Middle Atlantic	6.4	6.3	5.5	8.2	8.6	8.9	10.7	9.9	10.4	9.4	8.1	7.6	100.0
South Atlantic	7.6	7.3	7.7	8.4	8.3	8.7	9.4	9.1	8.5	8.6	8.3	8.1	100.0
Average	6.8	6.7	6.7	8.2	8.5	8.8	10.1	9.7	9.6	9.1	8.1	7.7	100.0
Central regions:													
East North Central	6.7	6.7	7.6	8.6	9.5	9.1	9.6	10.5	9.6	8.9	6.9	6.3	100.0
East South Central	6.4	6.9	7.4	8.0	8.5	8.4	9.0	10.0	9.3	9.1	8.6	8.4	100.0
West North Central	6.2	6.5	6.9	7.8	8.5	9.3	9.9	10.5	9.9	9.4	7.9	7.2	100.0
West South Central	7.0	7.4	7.8	8.3	8.4	8.7	8.9	9.0	8.7	8.7	8.6	8.5	100.0
Average	6.6	6.9	7.4	8.2	8.9	9.0	9.4	10.1	9.4	9.0	7.8	7.3	100.0
Western regions:													
Mountain	6.1	6.4	7.1	7.7	8.4	9.5	10.4	10.9	9.9	9.0	7.5	7.1	100.0
Pacific	6.5	7.0	7.4	7.9	8.6	9.2	9.9	10.5	9.6	8.7	7.7	7.0	100.0
Average	6.3	6.8	7.3	7.8	8.6	9.3	10.1	10.6	9.7	8.8	7.6	7.1	100.0
United States average	6.6	6.8	7.2	8.2	8.7	9.0	9.8	10.0	9.5	9.0	7.8	7.4	100.0

parison of 1947 traffic figures with those for 1941 shows that traffic was generally higher, month by month, in 1947 than in 1941 in the South Atlantic, Central, and Western regions, while travel in the New England and Middle Atlantic regions remained generally somewhat below the levels attained in the earlier year.

Table 2 indicates the differences in the regional annual traffic patterns for the year 1947. Normally, for the United States as a whole, the summer months of July and August have higher percentages of traffic than other months of the year. This is generally true for the year shown although, as would be expected, the variation is less marked in the South Atlantic and West South Central regions. In these regions storms and cold weather generally cut traffic less in winter than in the northern areas and also tourist and resort travel is relatively less in summer.

1947 SUMMER SURVEY

During the summer of 1947, the highway departments of 44 States, in cooperation with the Public Roads Administration, conducted a survey to obtain the trends in the volume and composition of traffic, and weights of trucks and truck combinations on rural roads. This survey followed, in general, similar surveys conducted each summer for the past 5 years.[2]

All States participated in these surveys except Wyoming, Maryland, Virginia, and Illinois. In Wyoming, an expanded weight survey was in progress but reports from it were not available for inclusion in this analysis.

The majority of weighing stations were operated during July, August, or September although Arizona, California, and Florida completed their work in June, Minnesota conducted the operations from May through August, and Mississippi operated for the entire year.

The stations used in these surveys were selected initially to give a representative cross section of traffic on main rural roads, and were operated generally for 8 hours on a weekday, either from 6 a. m. to 2 p. m. or from 2 p. m. to 10 p. m. All traffic passing through the stations during the period was counted and classified into the following categories: local passenger cars; foreign (out-of-State) passenger cars; panel and pick-up trucks;[3] other 2-axle, 4-tired trucks; 2-axle, 6-tired trucks; 3-axle trucks; tractor-semitrailer combinations; truck and trailer or tractor-semitrailer and trailer combinations; and busses.

The survey period, number of stations operated, number of vehicles counted, and number weighed are shown for each State in table 3. A total of 961,597 vehicles were counted at all stations during the period of the survey. Trucks and truck combinations numbered 192,341 or 20 percent of the total counted. Of these, 95,220 or 49.5 percent were stopped and weighed.

Wherever traffic volume permitted, all trucks and truck combinations were stopped and weighed. Where this procedure was impracticable, a sample was obtained by weighing all of the uncommon types and omitting only vehicles of types sufficiently common so that a partial sample would be adequate to establish their characteristics. The type of vehicle, whether it was loaded or empty, and the number of axles were recorded. The axle spacing and total wheelbase length of the heavier vehicles[4] were measured.

Table 4.—*Ratio of 1947 traffic to corresponding traffic in 1946, from summer counts*

Vehicle type	Eastern regions				Central regions					Western regions			United States average
	New England	Middle Atlantic	South Atlantic	Average	East North Central	East South Central	West North Central	West South Central	Average	Mountain	Pacific	Average	
Passenger cars:													
Local	1.13	1.07	1.24	1.15	1.06	1.13	1.18	0.97	1.07	1.20	1.08	1.10	1.10
Foreign	1.07	1.18	.88	1.00	1.24	1.08	.90	1.31	1.13	1.04	1.05	1.04	1.07
All passenger cars	1.11	1.09	1.13	1.11	1.10	1.11	1.10	1.03	1.09	1.12	1.07	1.09	1.09
Trucks and truck combinations:													
Single-unit trucks	1.04	1.15	1.19	1.16	1.19	1.10	1.16	1.10	1.14	1.12	1.37	1.25	1.16
Truck combinations	1.18	1.25	1.18	1.21	1.32	1.24	1.15	1.28	1.26	1.10	1.12	1.12	1.21
All trucks and truck combinations	1.06	1.18	1.19	1.17	1.23	1.13	1.16	1.14	1.17	1.12	1.26	1.20	1.18
Busses	1.00	1.14	1.18	1.14	1.08	.96	1.27	.96	1.06	1.15	.94	1.01	1.08
All vehicles	1.10	1.11	1.15	1.13	1.12	1.11	1.11	1.06	1.10	1.12	1.10	1.11	1 11

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[2] See *Traffic trends on rural roads in 1946*, by T. B. Dimmick and Mary E. Kipp, PUBLIC ROADS, vol. 25, No. 3, Mar. 1948; *Traffic trends on rural roads in 1945*, by T. B. Dimmick, PUBLIC ROADS, vol. 24, No. 10, Oct.-Nov.-Dec. 1946; and *Amount and characteristics of trucking on rural roads*, by J. T. Lynch and T. B. Dimmick, PUBLIC ROADS, vol. 23, No. 9, July-Aug.-Sept. 1943.

[3] Single units weighing less than 1½ tons.

[4] Single-unit trucks weighing 13 tons or more and truck combinations weighing 17 tons or more.

Passenger cars and busses were counted but not stopped for weighing.

Table 3.—*Survey period, number of stations operated, number of vehicles counted, and number weighed in each State in the special weight survey during the summer of 1947*

Region and State	Survey period	Number of stations	Vehicles counted		Trucks and combinations weighed
			All vehicles	Trucks and truck combinations	
New England:					
Connecticut	Sept. 8-22	10	26, 918	4, 815	2, 348
Maine	July 25-Aug. 26	10	25, 360	4, 138	1, 512
Massachusetts	Aug. 18-29	10	28, 565	4, 848	2, 219
New Hampshire	July 28-Aug. 1	5	13, 891	1, 714	548
Rhode Island	July 28-Aug. 1	5	11, 466	2, 096	970
Vermont	Aug. 4-8	5	8, 385	580	580
Subtotal		45	114, 585	18, 191	8, 177
Middle Atlantic:					
New Jersey	Aug. 4-Sept. 4	10	59, 277	11, 012	1, 878
New York	Sept. 22-26	20	36, 938	9, 515	3, 543
Pennsylvania	Aug. 6-19	10	36, 425	6, 432	1, 633
Subtotal		40	132, 640	26, 959	7, 054
South Atlantic:					
Delaware	Sept. 23-Oct. 2	4	11, 004	3, 148	447
Florida	June 9-30	10	12, 021	2, 170	2, 112
Georgia	Aug. 4-23	10	12, 635	2, 951	1, 804
Maryland	(1)				
North Carolina	Aug. 19-Sept. 9	12	23, 867	5, 546	3, 069
South Carolina	Sept. 22-Oct. 7	10	15, 147	3, 843	1, 923
Virginia	(1)				
West Virginia	Aug. 12-Sept. 5	9	10, 330	2, 735	1, 244
Subtotal		55	85, 004	20, 393	10, 599
Eastern regions, subtotal		140	332, 229	65, 543	25, 830
East North Central:					
Illinois	(1)				
Indiana	Aug. 4-29	20	36, 105	8, 261	3, 459
Michigan	July 24-Aug. 7	10	25, 942	4, 091	1, 896
Ohio	July 29-Aug. 14	10	21, 473	3, 740	1, 082
Wisconsin	Aug. 1-22	15	27, 316	3, 163	1, 804
Subtotal		55	110, 836	19, 255	8, 241
East South Central:					
Alabama	Aug. 14-Sept. 2	10	9, 591	2, 343	1, 425
Kentucky	June 19-July 24	10	10, 592	2, 584	948
Mississippi	Jan. 27-Dec. 17	15	17, 728	4, 785	3, 484
Tennessee	July 7-17	9	9, 087	2, 311	1, 484
Subtotal		44	46, 998	12, 023	7, 341
West North Central:					
Iowa	July 28-Aug. 8	10	11, 498	1, 960	1, 947
Kansas	Aug. 25-Sept. 8	10	8, 741	1, 799	1, 040
Minnesota	May 5-June 6 and July 7-Aug. 29	28	80, 009	15, 510	6, 227
Missouri	July 28-Aug. 15	42	75, 752	17, 725	11, 505
Nebraska	July 7-Aug. 13	20	18, 226	3, 844	3, 679
North Dakota	Aug. 1-28	10	13, 767	2, 781	1, 839
South Dakota	July 28-Aug. 14	9	4, 305	925	872
Subtotal		129	212, 298	44, 544	27, 109
West South Central:					
Arkansas	Aug. 4-15	10	13, 611	4, 276	1, 340
Louisiana	July 28-Aug. 8	10	7, 551	2, 337	2, 104
Oklahoma	Aug. 11-22	10	13, 747	3, 068	3, 068
Texas	June 17-Aug. 22	17	23, 728	5, 392	2, 273
Subtotal		47	58, 637	15, 073	8, 785
Central regions, subtotal		275	428, 769	90, 895	51, 476
Mountain:					
Arizona	June 9-20	10	8, 920	1, 672	661
Colorado	Aug. 15-29	10	23, 397	3, 866	1, 051
Idaho	Aug. 4-20	13	14, 016	2, 587	2, 069
Montana	July 30-Aug. 25	18	14, 640	3, 000	2, 393
Nevada	July 29-Aug. 12	10	6, 224	784	765
New Mexico	July 21-Aug. 7	10	9, 033	1, 901	1, 542
Utah	July 28-Aug. 8	10	15, 366	2, 649	851
Wyoming	(2)				
Subtotal		81	91, 596	16, 459	9, 332
Pacific:					
California	May 27-June 30	20	72, 375	13, 284	4, 117
Oregon	Aug. 11-29	9	19, 208	3, 582	2, 509
Washington	Sept. 3-16	10	17, 420	2, 578	1, 956
Subtotal		39	109, 003	19, 444	8, 582
Western regions, subtotal		120	200, 599	35, 903	17, 914
United States total		535	961, 597	192, 341	95, 220

[1] No survey made in 1947.
[2] Made an expanded survey in 1947 that is not comparable with previous counts.

TRAFFIC INCREASES

The ratios of 1947 summer traffic counts to corresponding counts in 1946 are given for the main vehicle types in table 4. The more detailed vehicle-type classification is not shown in this table because it was not made prior to 1947. Particularly noticeable in this table is the increase in trucks and truck combinations observed in every section of the country. The increase of single-unit trucks counted in the Pacific region and of truck combinations in the East North Central region is most noteworthy. In all regions except the New England and Mountain regions, truck and truck-combination traffic increased faster than passenger-car traffic. This was particularly true in the East North Central region where the passenger cars observed increased 10 percent while trucks and truck combinations increased 23 percent, and in the West South Central region where the passenger-car counts increased only 3 percent compared to an increase of 14 percent in the truck and truck-combination counts. Foreign passenger-car travel fell off surprisingly in the South Atlantic region and in the West North Central region.

Table 5 shows the percentage distribution of traffic by vehicle type in 1947. In this table the single-unit trucks are divided into the four new classification types that have been recommended by the Public Roads Administration and adopted by most of the States. The classification of trucks into these groups permits more positive identification than the use of the old "light, medium, and heavy" categories, and the groups are more homogeneous than those formerly used.

The percentage figures for the various types in table 5 indicate that the West South Central, East South Central, and Mountain regions have larger percentages of trucks than the areas with heavier travel such as New England, East North Central, Pacific, and Middle Atlantic regions. The table also shows that local conditions in some areas apparently encourage the use of certain types of vehicles, such as 2-axle, 6-tired trucks that are especially popular in the West North Central region, or the truck and trailer combinations that are used in the Pacific region to a greater extent than elsewhere in the country.

AVERAGE WEIGHTS NOW RELATIVELY STABLE

Figure 3 shows graphically the average weights of loaded and of empty single-unit trucks, of truck combinations, and of all trucks and truck combinations, in the summers of 1942 to 1947, inclusive, and in a corresponding period of a prewar year, generally 1936 or 1937. This chart shows that the weights of both loaded and empty single-unit trucks increased each year from the time of the first survey through 1945, and since then have decreased slightly. On the other hand, the weights of both loaded and empty truck combinations increased each year of the period shown. The average weights of the various types of loaded and empty trucks and truck combinations in the summer of 1947 are shown in table 6, for the different regions. This table brings out clearly the important differences that exist in the weight characteristics of the vehicles in the different groups of the new classification. It will be noted, for example, that for the United States as a whole the loaded 3-axle, single-unit trucks weighed

Table 5.—*Percentage distribution of traffic, by vehicle types, in the summer of 1947*

Vehicle types	Eastern regions				Central regions					Western regions			United States average
	New England	Middle Atlantic	South Atlantic	Average	East North Central	East South Central	West North Central	West South Central	Average	Moun-tain	Pacific	Average	
Passenger cars:													
Local	57.84	63.52	57.88	60.04	59.19	54.72	58.44	58.39	58.26	40.58	68.34	59.11	59.00
Foreign	24.68	15.09	17.22	17.45	23.00	21.82	18.07	15.87	19.92	36.33	11.50	19.75	19.08
All passenger cars	82.52	78.61	75.10	77.49	82.19	76.54	76.51	74.26	78.18	76.91	79.84	78.86	78.08
Single-unit trucks:													
Panel and pick-up	5.47	4.76	6.81	5.83	3.95	7.32	5.60	9.13	6.03	9.61	3.89	5.79	5.92
Other 2-axle, 4-tired	.53	1.54	.75	1.03	.20	.66	1.21	.63	.61	.43	1.63	1.23	.86
Other 2-axle, 6-tired	6.54	8.02	8.59	8.08	6.17	9.41	10.61	8.16	8.14	7.54	3.62	4.93	7.54
Three-axle	.34	.66	.88	.72	.66	.34	.21	.22	.40	.48	2.59	1.89	.77
All single-unit trucks	12.88	14.98	17.03	15.66	10.98	17.73	17.63	18.14	15.18	18.06	11.73	13.84	15.09
Truck combinations:													
Tractor-truck and semitrailer	3.18	5.31	6.23	5.45	5.82	4.05	4.66	6.30	5.44	3.30	4.49	4.10	5.19
Truck and trailer	.01	.03	.02	.02	.26	------	.22	.40	.25	.62	3.04	2.23	.54
All truck combinations	3.19	5.34	6.25	5.47	6.08	4.05	4.88	6.70	5.69	3.92	7.53	6.33	5.73
All trucks and truck combinations	16.07	20.32	23.28	21.13	17.06	21.78	22.51	24.84	20.87	21.98	19.26	20.17	20.82
Busses	1.41	1.07	1.62	1.38	.75	1.68	.98	.90	.95	1.11	.90	.97	1.10
All vehicles	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

more than twice as much as the 2-axle, 6-tired trucks, and that similar differences existed throughout the classification.

TRUCK TRANSPORTATION HAS PHENOMENAL INCREASE

Figure 4 shows a comparison of the estimated vehicle-miles of travel on main rural roads[5] of both the loaded and the empty single-unit trucks and truck combinations, separately and combined, for each year from 1936 to 1947, inclusive. This chart shows more clearly than figure 2 the steady growth of truck traffic during the period 1936–41, the temporary effect of the wartime restrictions, and the phenomenal upsurge in highway truck transportation since the war. Travel by single-unit trucks in 1947 increased 16 percent above that for 1946; that of truck combinations increased 21 percent; and that of all types increased 18 percent. The increases of travel by loaded vehicles, considered separately from empty vehicles, were even greater. Travel by loaded single-unit trucks in 1947 increased 21 percent above that for 1946; that of truck combinations increased 23 percent; and that of all types increased 22 percent.

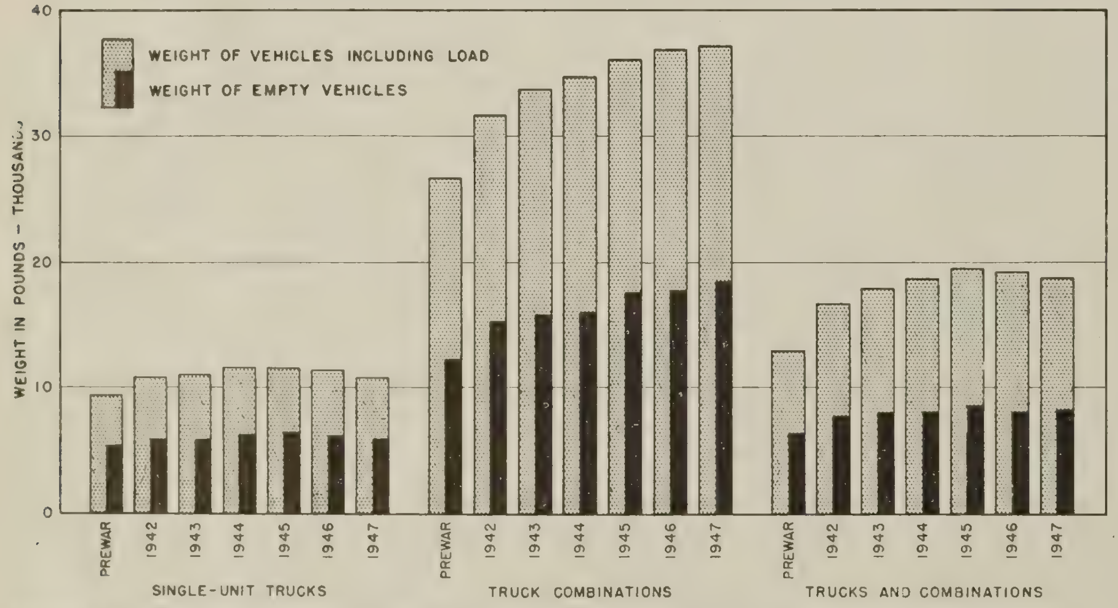

Figure 3.—Average weights of loaded and of empty trucks and truck combinations in the summers of 1942–47 and in a corresponding period of a prewar year.

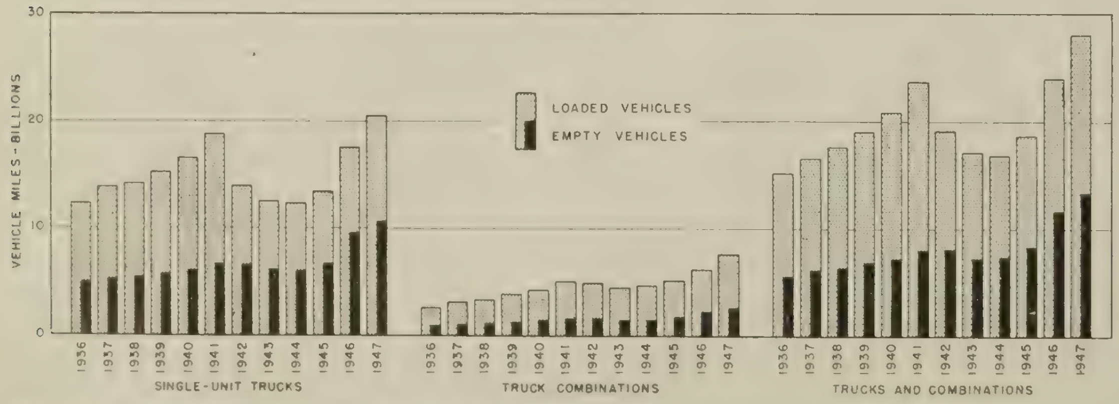

Figure 4.—Travel on main rural roads by loaded and empty trucks and truck combinations.

Table 7 gives a comparison, by regions, of the estimated vehicle-miles of travel by vehicles of different types on all main rural roads in 1947 and 1946. While total travel increased a considerable amount (11 percent) over the previous year's total, even larger increases were found in the travel by freight-carrying vehicles. These increases were indicated in every census region but were more noticeable in the Pacific region, where truck and truck-combination traffic increased 26 percent over the previous total, and in the East North Central region where it increased 23 percent above the 1946 estimate.

A second important trend that is indicated by the figures in table 7 is the continued increase found in many sections of the country in the more general use of the heavier commercial vehicles. In every region east of the Rocky Mountain States, except in the West North Central and the South Atlantic regions, the vehicle-mileage of truck combinations increased more rapidly than that of single-unit trucks. In the Pacific region, on the other hand, where the use of loaded truck combinations had increased phenomenally in previous years, the vehicle-mileage of this type increased only 12 percent as compared to 37 percent for single-unit trucks.

Figure 5 gives a comparison of the average load carried by single-unit trucks,truck combinations, and all of these vehicles combined, in the 12 years since the planning surveys were commenced in 1936. The chart shows the general upward trend of load weights throughout all except the last 2 years of this period. In 1947 the average carried load both of single-unit trucks and of truck combinations declined slightly from the 1946 level but, because of the increased proportion of combinations, the average for all vehicles remained practically constant. From 1936 to 1947 the average carried load on single-unit trucks increased from 1.9 tons to 2.3 tons, an increase of 21 percent; the average

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[5] Main rural roads, as referred to in this article, comprise about 345,000 miles of the principal routes in the United States.

Table 6.—*Average weights (in pounds) of loaded and empty trucks and truck combinations, by vehicle types, in the summer of 1947*

Vehicle type	Eastern regions				Central regions					Western regions			United States average
	New England	Middle Atlantic	South Atlantic	Average	East North Central	East South Central	West North Central	West South Central	Average	Mountain	Pacific	Average	
AVERAGE WEIGHTS OF LOADED TRUCKS													
Single-unit trucks:													
Panel and pick-up	6,321	4,774	5,127	5,187	5,462	4,990	4,800	5,378	5,199	5,681	4,070	4,660	5,109
Other 2-axle, 4-tired	9,320	7,044	8,770	7,872	8,120	6,207	6,738	7,897	7,227	8,580	8,258	8,277	7,816
Other 2-axle, 6-tired	14,544	14,216	12,221	13,227	13,485	12,685	12,420	12,452	12,805	13,193	11,246	12,083	12,871
Three-axle	29,355	28,122	24,104	25,595	32,809	28,920	24,115	24,308	30,676	24,837	25,169	25,145	26,711
Average	11,779	11,786	10,247	10,978	12,314	10,963	10,127	9,038	10,622	10,776	11,774	11,507	10,897
Truck combinations:													
Tractor-truck and semitrailer	37,141	39,358	34,726	36,557	35,422	30,704	36,711	32,122	34,371	40,843	45,179	44,059	36,594
Truck and trailer	(1)	(1)	(1)	(1)	57,614	----------	19,081	19,704	33,259	51,630	52,378	52,099	46,574
Average	37,223	39,293	34,713	36,560	36,405	30,704	35,600	31,197	34,312	42,215	47,771	46,625	37,498
Average, all trucks and truck combinations	18,196	20,341	16,792	18,214	23,663	16,396	16,869	15,639	18,862	19,427	22,028	21,111	19,047
AVERAGE WEIGHTS OF EMPTY TRUCKS													
Single-unit trucks:													
Panel and pick-up	4,689	3,976	3,744	3,937	4,109	3,943	3,730	4,273	4,057	3,967	3,468	3,777	3,965
Other 2-axle, 4-tired	7,103	4,992	5,740	5,327	6,110	4,680	4,718	5,339	5,060	5,221	5,545	5,485	5,271
Other 2-axle, 6-tired	8,412	6,137	6,898	6,779	6,991	7,172	7,160	7,189	7,129	7,184	7,514	7,328	7,036
Three-axle	16,899	13,339	11,054	12,480	15,048	11,835	12,248	12,099	13,766	13,514	14,605	14,515	13,777
Average	6,719	6,687	5,456	6,073	6,046	5,502	5,730	5,579	5,716	5,244	7,324	6,267	5,932
Truck combinations:													
Tractor-truck and semitrailer	20,499	19,605	17,075	18,399	18,344	15,813	17,765	15,830	17,094	20,429	21,100	20,814	17,942
Truck and trailer	(1)	(1)	(1)	(1)	24,391	----------	11,609	15,773	20,130	28,252	21,930	22,982	21,933
Average	20,498	19,623	17,072	18,405	18,871	15,813	17,528	15,816	17,249	21,778	21,531	21,606	18,304
Average, all trucks and truck combinations	8,536	9,110	7,484	8,232	9,854	6,555	7,834	8,017	8,153	7,228	10,520	8,959	8,321

[1] Data omitted because of insufficient sample.

Table 7.—*Comparison of estimated 1947 vehicle-miles of travel on main rural roads with corresponding figures for 1946*

Region and year	All vehicles, vehicle-miles	Passenger cars and busses [1]		All trucks and truck combinations		Single-unit trucks		Truck combinations	
		Percentage of all vehicles	Vehicle-miles	Percentage of all vehicles	Vehicle-miles	Percentage of all trucks and truck combinations	Vehicle-miles	Percentage of all trucks and truck combinations	Vehicle-miles
Eastern regions:									
New England:	*Thousands*		*Thousands*		*Thousands*		*Thousands*		*Thousands*
1946	5,713,086	83.3	4,759,184	16.7	953,902	82.1	783,031	17.9	170,871
1947	6,298,391	83.9	5,286,129	16.1	1,012,262	80.1	811,285	19.9	200,977
1947: 1946 ratio	1.10	1.01	1.11	.96	1.06	.98	1.04	1.11	1.18
Middle Atlantic:									
1946	15,532,600	80.9	12,564,265	19.1	2,968,335	75.3	2,234,986	24.7	733,349
1947	17,207,662	79.7	13,711,322	20.3	3,496,340	73.7	2,577,225	26.3	919,115
1947: 1946 ratio	1.11	.99	1.09	1.06	1.18	.98	1.15	1.06	1.25
South Atlantic:									
1946	18,439,919	77.5	14,290,746	22.5	4,149,173	72.9	3,025,426	27.1	1,123,747
1947	21,193,968	76.7	16,260,267	23.3	4,933,701	73.2	3,609,723	26.8	1,323,978
1947: 1946 ratio	1.15	.99	1.14	1.04	1.19	1.00	1.19	.99	1.18
Subtotal:									
1946	39,685,605	79.7	31,614,195	20.3	8,071,410	74.9	6,043,443	25.1	2.027,967
1947	44,700,021	78.9	35,257,718	21.1	9,442,303	74.1	6,998,233	25.9	2,444,070
1947: 1946 ratio	1.13	.99	1.12	1.04	1.17	.99	1.16	1.03	1.21
Central regions:									
East North Central:									
1946	23,563,034	84.4	19,898,197	15.6	3,664,837	66.7	2,444,116	33.3	1,220,721
1947	26,432,337	82.9	21,923,580	17.1	4,508,757	64.4	2,902,341	35.6	1,606,416
1947: 1946 ratio	1.12	.98	1.10	1.10	1.23	.97	1.19	1.07	1.32
East South Central:									
1946	7,470,206	78.5	5,867,331	21.5	1,602,875	83.1	1,332,105	16.9	270,770
1947	8,288,771	78.2	6,482,965	21.8	1,805,806	81.4	1,469,955	18.6	335,851
1947: 1946 ratio	1.11	.99	1.10	1.01	1.13	.98	1.10	1.10	1.24
West North Central:									
1946	14,971,991	78.5	11,755,049	21.5	3,216,942	78.2	2,514,597	21.8	702,345
1947	16,528,990	77.5	12,807,372	22.5	3,721,618	78.3	2,914,132	21.7	807,486
1947: 1946 ratio	1.10	.99	1.09	1.05	1.16	1.00	1.16	1.00	1.15
West South Central:									
1946	15,721,893	77.2	12,130,839	22.8	3,591,054	75.9	2,724,193	24.1	866,861
1947	16,533,940	75.2	12,426,948	24.8	4,106,992	73.0	2,998,788	27.0	1,108,204
1947: 1946 ratio	1.05	.97	1.02	1.09	1.14	.96	1.10	1.12	1.28
Subtotal:									
1946	61,727,124	80.4	49,651,416	19.6	12,075,708	74.7	9,015,011	25.3	3,060,697
1947	67,784,038	79.1	53,640,865	20.9	14,143,173	72.7	10,285.216	27.3	3,857.957
1947: 1946 ratio	1.10	.98	1.08	1.07	1.17	.97	1.14	1.08	1.26
Western regions:									
Mountain:									
1946	7,476,867	78.1	5,837,284	21.9	1,639,583	82.0	1,343,755	18.0	295,828
1947	8,324,525	78.0	6,495,071	22.0	1,829,454	82.2	1,503,184	17.8	326,270
1947: 1946 ratio	1.11	1.00	1.11	1.00	1.12	1.00	1.12	.99	1.10
Pacific:									
1946	15,259,494	83.2	12,700,388	16.8	2,559,106	56.1	1,435,685	43.9	1,123,421
1947	16,703.515	80.7	13,486,242	19.3	3,217,273	60.9	1,959,729	39.1	1,257,544
1947: 1946 ratio	1.09	.97	1.06	1.15	1.26	1.09	1.37	.89	1.12
Subtotal:									
1946	22,736,361	81.5	18,537,672	18.5	4,198,689	66.2	2,779,440	33.8	1,419,249
1947	25,028,040	79.8	19,981,313	20.2	5,046,727	68.6	3,462,913	31.4	1,583,814
1947: 1946 ratio	1.10	.98	1.08	1.09	1.20	1.04	1.25	.93	1.12
United States total:									
1946	124,149,090	80.4	99,803.283	19.6	24,345,807	73.3	17,837,894	26.7	6,507.913
1947	137,512,099	79.2	108,879,896	20.8	28,632,203	72.5	20,746,362	27.5	7,885,841
1947: 1946 ratio	1.11	.99	1.09	1.06	1.18	.99	1.16	1.03	1.21

[1] Percentages of total 1947 travel by passenger cars and by busses is reported separately in table 5.

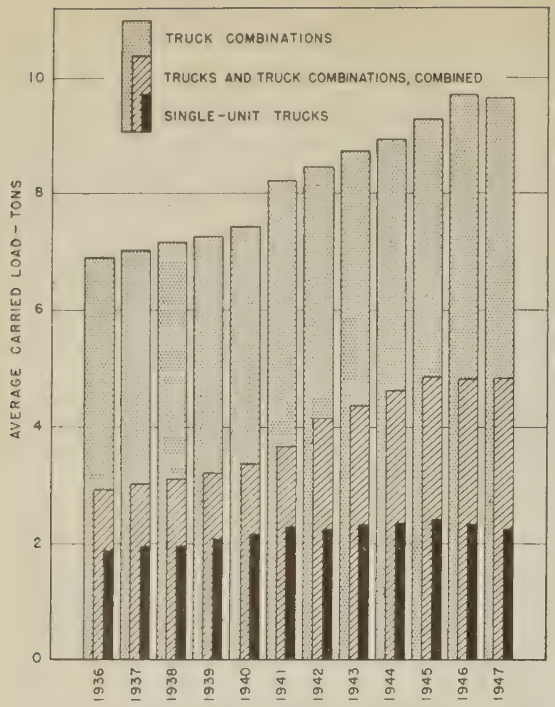

Figure 5.—Average load carried by trucks and truck combinations on main rural roads, 1936–47.

load carried by truck combinations increased from 6.9 tons to 9.6 tons, or 39 percent; and the average of all types combined increased from 2.9 tons to 4.8 tons, or 66 percent.

Figure 6 shows a comparison, for each year from 1936 through 1947, of the ton-miles of freight carried by trucks and truck combinations on main rural roads. The chart demonstrates how truck combinations are transporting each year a larger portion of the total amount of highway freight. In 1936 the truck combinations accounted for approximately the same ton-mileage as the single-unit trucks while in 1947 the ratio increased to more than two to one. The sharp increase in the total ton-mileage during the last 3 years is especially striking.

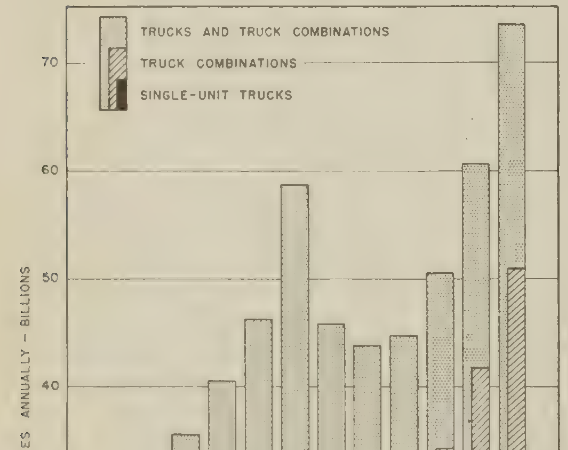

Figure 6.—Estimated ton-miles carried by trucks and truck combinations on main rural roads, 1936–47.

GREATER PERCENTAGE OF LOADED TRUCKS

In table 8 is shown a comparison of the percentage of vehicles carrying loads, the average carried load, and the ton-mileage carried for all trucks and combinations, for single-unit trucks, and for truck combinations in 1947 and in 1946, by census regions. For the country as a whole, from 1946 to 1947 the percentage of trucks and truck combinations carrying loads increased from 51.7 percent to 53.5 percent, that of single-unit trucks increased from 46.4 percent to 48.3 percent, while that of truck combinations increased from 66.2 percent to 67.1 percent. These increases are particularly interesting because they reverse a trend of decreasing percentages of loaded vehicles that had prevailed since the beginning of the war, due probably to the use of trucks as passenger cars during the period of gasoline rationing and vehicle shortage. It is to be noted than even in 1947, over half of the single-unit trucks were empty, which may reflect the continuing shortage of new automobiles.

As pointed out in the discussion of figure 5, the average carried loads for the country as a whole were about the same in 1947 as in 1946. Table 8 shows that there was no great change in any of the regions, the greatest increase being 7 percent in the Middle Atlantic region and the greatest decrease being 9 percent in the Pacific region.

The ton-mileage transported by all types of freight-carrying vehicles, traveling on main rural roads, increased about 21 percent in 1947 compared to 1946; that by single-unit trucks increasing 18 percent, and that by truck combinations increasing 22 percent. Increases of the 1947 estimates over those for 1946 were found in every region both for single-unit trucks and for truck combinations. The percentage increases for trucks and truck combinations combined ranged from 9 percent in the

Table 8.—*Comparison of the estimated 1947 percentage of trucks and truck combinations loaded, average carried load, and ton-miles carried on main rural roads, with corresponding figures for 1946*

Region and year	All trucks and truck combinations			Single-unit trucks			Truck combinations		
	Percentage loaded	Average weight of carried load	Ton-miles carried	Percentage loaded	Average weight of carried load	Ton-miles carried	Percentage loaded	Average weight of carried load	Ton-miles carried
Eastern regions:									
New England:		*Tons*	*Thousands*		*Tons*	*Thousands*		*Tons*	*Thousands*
1946	52.4	3.99	1,995,842	48.2	2.24	844,357	57.2	9.40	1,151,485
1947	54.1	3.99	2,187,043	50.5	2.10	860,482	69.0	9.56	1,326,561
1947: 1946 ratio	1.03	1.00	1.10	1.05	.94	1.02	1.21	1.02	1.15
Middle Atlantic:									
1946	57.7	4.10	7,023,600	55.8	2.18	2,719,736	63.4	9.25	4,303,864
1947	52.1	4.40	8,025,404	48.9	2.35	2,965,474	61.2	8.99	5,059,930
1947: 1946 ratio	.90	1.07	1.14	.88	1.08	1.09	.97	.97	1.18
South Atlantic:									
1946	53.5	4.79	10,637,066	48.4	2.38	3,494,145	67.0	9.48	7,142,921
1947	55.7	4.55	12,505,330	51.6	2.16	4,021,377	66.8	9.58	8,483,953
1947: 1946 ratio	1.04	.95	1.18	1.07	.91	1.15	1.00	1.01	1.19
Subtotal:									
1946	54.9	4.44	19,656,508	51.1	2.29	7,058,238	66.1	9.39	12,598,270
1947	54.2	4.44	22,717,777	50.4	2.22	7,847,333	64.9	9.37	14,870,444
1947: 1946 ratio	.99	1.00	1.16	.99	.97	1.11	.98	1.00	1.18
Central regions:									
East North Central:									
1946	57.2	4.81	10,081,218	50.5	2.17	2,685,088	70.6	8.59	7,396,130
1947	59.1	4.92	13,116,456	52.8	2.18	3,337,759	70.5	8.63	9,778,697
1947: 1946 ratio	1.03	1.02	1.30	1.05	1.00	1.24	1.00	1.00	1.32
East South Central:									
1946	42.7	4.04	2,761,538	38.6	2.54	1,304,071	62.6	8.60	1,457,467
1947	44.6	4.21	3,384,394	39.4	2.52	1,455,767	67.3	8.54	1,928,627
1947: 1946 ratio	1.04	1.04	1.23	1.02	.99	1.12	1.08	.99	1.32
West North Central:									
1946	55.1	3.72	6,585,211	52.2	1.97	2,582,219	65.2	8.74	4,002,992
1947	55.9	3.77	7,831,725	53.0	1.93	2,984.823	66.3	9.05	4,846,902
1947: 1946 ratio	1.01	1.01	1.19	1.02	.98	1.16	1.02	1.04	1.21
West South Central:									
1946	36.6	4.16	5,461,533	31.3	2.65	2,264,895	53.2	6.93	3,196,638
1947	46.1	4.14	7,832,121	41.2	2.51	3,105,980	59.3	7.19	4,726,141
1947: 1946 ratio	1.26	.99	1.43	1.32	.95	1.37	1.11	1.04	1.48
Subtotal:									
1946	48.6	4.24	24,889,500	43.4	2.26	8,836,273	63.7	8.23	16,053,227
1947	52.6	4.32	32,164,696	47.6	2.22	10,884,329	66.1	8.34	21,280,367
1947: 1946 ratio	1.08	1.02	1.29	1.10	.98	1.23	1.04	1.01	1.33
Western regions:									
Mountain:									
1946	43.3	4.88	3,463,639	38.1	2.59	1,327,577	66.8	10.81	2,136,062
1947	39.8	5.16	3,763,238	34.5	2.61	1,354,717	64.4	11.48	2,408,521
1947: 1946 ratio	.92	1.06	1.09	.91	1.01	1.02	.96	1.06	1.13
Pacific:									
1946	62.0	8.12	12,882,143	53.3	2.45	1,878,801	73.1	13.40	11,003,342
1947	62.8	7.40	14,964,484	54.9	2.35	2,523,948	75.3	13.14	12,440.536
1947: 1946 ratio	1.01	.91	1.16	1.03	.96	1.34	1.03	.98	1.13
Subtotal:									
1946	54.7	7.12	16,345,782	46.0	2.51	3,206,378	71.8	12.90	13,139,404
1947	54.5	6.81	18,727,722	46.0	2.43	3,878,665	73.0	12.84	14,849,057
1947: 1946 ratio	1.00	.96	1.15	1.00	.97	1.21	1.02	1.00	1.13
United States total:									
1946	51.7	4.84	60,891,790	46.4	2.31	19,100,889	66.2	9.70	41,790,901
1947	53.5	4.81	73,610,195	48.3	2.26	22,610.327	67.1	9.63	50,999,868
1947: 1946 ratio	1.03	.99	1.21	1.04	.98	1.18	1.01	.99	1.22

Table 9.—*Percentage of vehicle-miles of travel, percentage loaded, average carried load, and percentage of total ton-miles carried by various types of trucks and truck combinations on main rural roads in the summer of 1947*

Vehicle type	Eastern regions				Central regions					Western regions			United States average
	New England	Middle Atlantic	South Atlantic	Average	East North Central	East South Central	West North Central	West South Central	Average	Mountain	Pacific	Average	
PERCENTAGE OF VEHICLE-MILES OF TRAVEL													
Single-unit trucks:													
Panel and pick-up	34.02	23.42	29.25	27.60	23.15	33.59	24.88	36.77	28.89	43.73	20.19	28.72	28.44
Other 2-axle, 4-tired	3.30	7.60	3.23	4.86	1.19	3.03	5.36	2.51	2.91	1.96	8.49	6.12	4.12
Other 2-axle, 6-tired	40.68	39.46	36.91	38.26	36.19	43.19	47.14	32.85	38.99	34.32	18.80	27.43	36.18
Three-axle	2.15	3.23	3.77	3.40	3.84	1.59	.92	.89	1.93	2.16	13.43	9.35	3.72
All single-unit trucks	80.15	73.71	73.16	74.12	64.37	81.40	78.30	73.02	72.72	82.17	60.91	68.62	72.46
Truck combinations:													
Tractor-truck and semitrailer	19.76	26.15	26.77	25.79	34.12	18.60	20.73	25.36	26.07	15.01	23.33	20.31	24.96
Truck and trailer	.09	.14	.07	.09	1.51	------	.97	1.62	1.21	2.82	15.76	11.07	2.58
All truck combinations	19.85	26.29	26.84	25.88	35.63	18.60	21.70	26.98	27.28	17.83	39.09	31.38	27.54
All trucks and truck combinations	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
PERCENTAGE LOADED													
Single-unit trucks:													
Panel and pick-up	44.6	41.6	42.1	42.3	42.6	25.9	44.9	38.8	39.2	23.7	45.7	33.5	39.2
Other 2-axle, 4-tired	53.8	38.7	49.2	43.4	61.8	39.0	50.6	46.9	49.6	36.3	67.3	63.7	50.9
Other 2-axle, 6-tired	54.9	55.3	58.0	56.6	58.1	49.3	57.5	43.7	53.1	47.4	60.0	53.6	54.4
Three-axle	54.7	47.6	64.2	57.7	62.1	54.8	56.0	34.6	56.9	48.9	53.6	53.2	55.5
Average	50.5	48.9	51.6	50.4	52.8	39.4	53.0	41.2	47.6	34.5	54.9	46.0	48.3
Truck combinations:													
Tractor-truck and semitrailer	68.9	61.1	66.7	64.8	71.2	67.3	65.9	58.2	66.1	65.6	80.7	76.7	67.2
Truck and trailer	88.6	86.2	72.8	81.5	54.9	------	75.2	76.2	67.5	57.4	67.3	66.3	66.8
Average	69.0	61.2	66.8	64.9	70.5	67.3	66.3	59.3	66.1	64.4	75.3	73.0	67.1
Average, all trucks and truck combinations	54.1	52.1	55.7	54.2	59.1	44.6	55.9	46.1	52.6	39.8	62.8	54.5	53.5
AVERAGE CARRIED LOAD, IN TONS													
Single-unit trucks:													
Panel and pick-up	.73	.42	.64	.59	.61	.54	.52	.82	.66	.96	.46	.65	.63
Other 2-axle, 4-tired	1.43	.93	1.45	1.18	.92	.86	1.02	1.79	1.17	1.94	1.51	1.54	1.29
Other 2-axle, 6-tired	2.87	3.01	2.69	2.83	2.66	3.12	2.55	4.13	2.98	3.41	2.39	2.85	2.91
Three-axle	6.31	8.05	5.66	6.39	4.79	9.77	5.15	8.53	5.65	6.46	5.38	5.47	5.80
Average	2.10	2.35	2.16	2.22	2.18	2.52	1.93	2.51	2.22	2.61	2.35	2.43	2.26
Truck combinations:													
Tractor-truck and semitrailer	9.50	9.00	9.59	9.36	8.36	8.54	9.36	7.50	8.37	10.87	11.97	11.72	9.25
Truck and trailer	18.99	8.66	7.81	9.53	16.60	------	3.21	3.61	7.72	15.15	15.22	15.22	13.38
Average	9.56	8.99	9.58	9.37	8.63	8.54	9.05	7.19	8.34	11.48	13.14	12.84	9.63
Average, all trucks and truck combinations	3.99	4.40	4.55	4.44	4.92	4.21	3.77	4.14	4.32	5.16	7.40	6.81	4.81
PERCENTAGE OF TON-MILEAGE CARRIED													
Single-unit trucks:													
Panel and pick-up	5.12	1.79	3.11	2.84	2.08	2.51	2.74	6.16	3.28	4.82	.90	1.69	2.74
Other 2-axle, 4-tired	1.18	1.19	.91	1.03	.23	.54	1.32	1.10	.74	.67	1.86	1.62	1.06
Other 2-axle, 6-tired	29.62	28.58	22.73	25.46	19.21	35.41	32.79	31.03	27.10	27.10	5.79	10.07	22.26
Three-axle	3.42	5.39	5.41	5.21	3.93	4.55	1.26	1.37	2.72	3.41	8.32	7.33	4.66
All single-unit trucks	39.34	36.95	32.16	34.54	25.45	43.01	38.11	39.66	33.84	36.00	16.87	20.71	30.72
Truck combinations:													
Tractor-truck and semitrailer	59.95	62.60	67.69	65.15	69.83	56.99	60.78	58.00	63.40	52.07	48.44	49.17	60.32
Truck and trailer	.71	.45	.15	.31	4.72	------	1.11	2.34	2.76	11.93	34.69	30.12	8.96
All truck combinations	60.66	63.05	67.84	65.46	74.55	56.99	61.89	60.34	66.16	64.00	83.13	79.29	69.28
All trucks and truck combinations	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Mountain region to 43 percent in the West South Central region.

Table 9 gives detailed information concerning the percentage distribution of vehicle-miles of travel, the percentage of vehicles carrying loads, the average carried load, and the percentage distribution of ton-miles transported by each type of vehicle in each of the census regions. Many interesting and useful comparisons can be made from this table. For instance, while panel and pick-up trucks in the New England region travel 34 percent of the vehicle-miles, they account for only 5 percent of the ton-mileage; in the same region the tractor-semitrailer combinations travel less than 20 percent of the vehicle-miles but account for almost 60 percent of the ton-mileage.

From the portion of table 9 showing the percentage of vehicles carrying loads, by types, it can be observed that, for the country as a whole, the panel and pick-up trucks are found empty over 60 percent of the time, probably indicating that they are being used frequently for the transportation of persons in lieu of passenger cars. The percentage of vehicles carrying loads increases directly as the size of the vehicle type, and the truck-combination type is loaded 67 percent of the time. There are variations from the general trend in some regions because of local conditions, as would be expected.

The detailed data concerning the average carried load for the various vehicle types show that carried loads increase regularly as the size of the vehicle-type increases except that, in some regions, average carried load for the truck and trailer combinations is low, probably due to the prevalence of light home-made types of trailers.

The percentages of ton-mileage carried by vehicle types are particularly useful in judging the relative importance of any portion of the freight-carrying traffic. The table shows that the bulk of all freight movement in each area is hauled in the heavier vehicles. As has been pointed out previously, the data collected in past surveys indicate that travel by the heavier vehicles is steadily increasing, a fact that will make a comparison of future tables of this type with that for 1947 of great importance.

Figure 7 shows, for the United States as a whole, the frequency of gross weights of 30,000 pounds or more, of 40,000 pounds or more, and of 50,000 pounds or more. These heavy weights are much more frequent than in the prewar (1936–41) period. The frequency in the heaviest category did not increase from 1946 to 1947, however, and those in the other two categories declined somewhat, indicating that the upward trend in gross weight frequencies may have been halted, at least temporarily.

The gross weight data by vehicle type and region are presented in table 10. Heavy gross

Table 10.—*Number of heavy gross weights per 1,000 loaded and empty trucks and truck combinations of various types on main rural roads in the summer of 1947 and of all types in the corresponding period of 1946*

Vehicle type	Eastern regions				Central regions					Western regions			United States average
	New England	Middle Atlantic	South Atlantic	Average	East North Central	East South Central	West North Central	West South Central	Average	Moun-tain	Pacific	Average	
NUMBER PER 1,000 WEIGHING 30,000 POUNDS OR MORE													
Single-unit trucks:													
Panel and pick-up	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2-axle, 4-tired	3	0	0	(1)	0	0	0	0	0	0	0	0	(1)
Other 2-axle, 6-tired	22	16	1	9	0	0	1	(1)	(1)	1	1	1	3
Three-axle	251	181	102	140	230	164	96	80	187	123	186	181	171
Average	18	12	4	9	4	3	2	1	2	4	21	14	6
Truck combinations:													
Tractor-truck and semitrailer	515	432	427	436	480	426	484	332	432	475	578	548	449
Truck and trailer	689	99	0	121	651	0	2	110	413	723	712	713	617
Average	516	430	427	436	490	426	464	319	431	519	628	603	464
Average, all trucks and truck combinations, 1947	127	116	95	107	154	79	123	87	116	90	197	158	120
Average, all trucks and truck combinations, 1946	118	149	125	133	194	121	112	65	124	92	193	154	132
NUMBER PER 1,000 WEIGHING 40,000 POUNDS OR MORE													
Single-unit trucks:													
Panel and pick-up	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2-axle, 4-tired	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2-axle, 6-tired	1	1	0	(1)	0	0	0	0	0	0	(1)	(1)	(1)
Three-axle	115	31	0	19	10	32	9	35	15	24	28	27	22
Average	3	2	0	1	(1)	1	(1)	(1)	(1)	1	3	2	1
Truck combinations:													
Tractor-truck and semitrailer	285	215	173	198	227	132	236	114	187	273	433	385	217
Truck and trailer	689	0	0	67	465	0	0	75	236	436	453	451	386
Average	292	213	173	198	241	132	224	112	189	298	441	408	232
Average, all trucks and truck combinations, 1947	64	55	39	48	76	25	55	31	50	52	120	95	57
Average, all trucks and truck combinations, 1946	53	80	44	58	80	41	45	18	47	53	133	102	60
NUMBER PER 1,000 WEIGHING 50,000 POUNDS OR MORE													
Single-unit trucks:													
Panel and pick-up	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2-axle, 4-tired	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2-axle, 6-tired	0	0	0	0	0	0	0	0	0	0	0	0	0
Three-axle	11	0	0	1	10	0	9	18	10	0	0	0	3
Average	(1)	0	0	(1)	(1)	0	(1)	(1)	(1)	0	0	0	(1)
Truck combinations:													
Tractor-truck and semitrailer	74	58	34	46	88	14	93	26	64	150	314	265	84
Truck and trailer	689	0	0	67	356	0	0	75	182	321	371	366	163
Average	82	57	34	47	104	14	88	29	70	180	337	301	92
Average, all trucks and truck combinations, 1947	17	14	8	11	45	3	20	8	22	31	87	67	26
Average, all trucks and truck combinations, 1946	9	25	6	13	36	4	14	6	17	31	104	75	26

[1] Less than 5 in 10,000.

weights are much more frequent in the Pacific region than in other parts of the country: 87 out of each 1,000 trucks and truck combinations on the main rural highways, empties included, weighed 50,000 pounds or more in 1947. This, however, is a drop from the 1946 figure of 104 for each 1,000 in this heavy category. These vehicles are entirely of the truck-combination type; approximately one-third of all combinations observed, or approximately one-half of the loaded ones, weighing 50,000 pounds or more. In the South Atlantic and the two South Central regions, these heavy gross weights were less than one-tenth as frequent as in the Pacific region.

HEAVY AXLE LOADS MORE FREQUENT

From figure 8, the rapid increase in heavy axle-load frequencies since the prewar (1936–41) period is apparent. Axle loads in excess of 22,000 pounds increased in frequency year by year throughout the period, rising from 2 per 1,000 vehicles in the prewar years to 14 per 1,000 vehicles in 1947, an increase of almost 600 percent. Somewhat lesser increases occurred in the frequencies of axle loads from 18,000 to 22,000 pounds.

Since the increases in axle-load frequencies are of the greatest significance in road and bridge design, it is worth while to examine the data by vehicle type and region, as presented in table 11. Though the greatest frequency of heavy gross weights is in the Pacific region, as previously shown, the lowest frequency of heavy axle loads is in that same region. The greatest frequency is in the Middle Atlantic region, and the next greatest in the New England region. Further, the frequency of axle loads of 22,000 pounds or more increased from 1946 to 1947 in each region except the Pacific and Mountain regions, where the comparatively low values of 1946 continued to prevail.

The relative infrequency of heavy axle loads in the Pacific region in the presence of a high frequency of heavy gross weights undoubtedly indicates a better distribution of load over a larger number of axles, on the average. In the Middle Atlantic and New England regions, however, it is the tractor-truck-semitrailer combinations rather than single-unit trucks which account for most of the heavy axle loads. This may be due to differences in the design of the prevalent types of combinations, to differences in State laws, or to differences in enforcement practices.

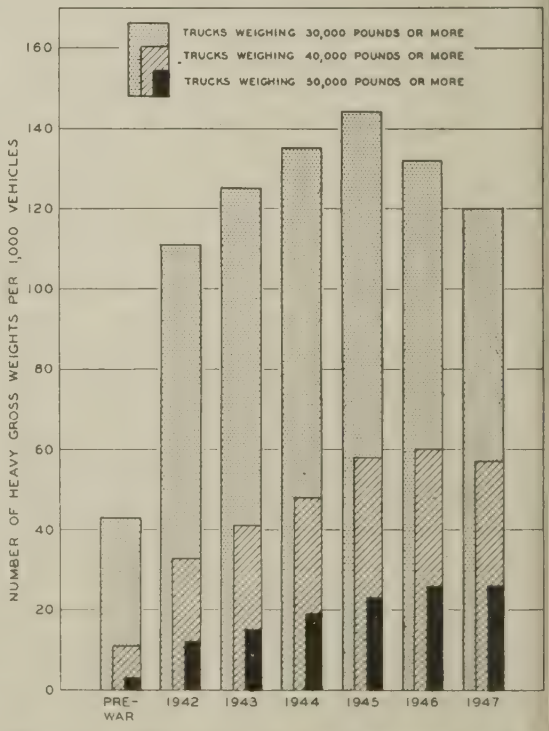

Figure 7.—Number of heavy gross weights per 1,000 trucks and truck combinations (empties included) in the summers of 1942–47 and a prewar year.

able 11.—*Number of heavy axle loads per 1,000 loaded and empty trucks and truck combinations of various types on main rural roads in the summer of 1947 and of all types in 1946*

Vehicle type	Eastern regions: New England	Eastern regions: Middle Atlantic	Eastern regions: South Atlantic	Eastern regions: Average	Central regions: East North Central	Central regions: East South Central	Central regions: West North Central	Central regions: West South Central	Central regions: Average	Western regions: Mountain	Western regions: Pacific	Western regions: Average	United States average
NUMBER PER 1,000 WEIGHING 18,000 POUNDS OR MORE													
Single-unit trucks:													
Panel and pick-up	0	1	0	(1)	0	3	0	0	(1)	0	0	0	(1)
Other 2-axle, 4-tired	10	0	0	1	0	0	0	0	0	0	0	0	(1)
Other 2-axle, 6-tired	51	47	13	30	8	22	5	6	9	15	15	15	17
Three-axle	105	46	15	32	65	37	23	38	53	32	33	33	38
Average	28	32	7	19	6	14	3	3	5	7	15	12	7
Truck combinations:													
Tractor-truck and semitrailer	401	510	282	380	223	200	226	152	200	189	145	158	258
Truck and trailer	0	100	0	55	473	0	2	123	252	77	68	69	116
Average	401	508	281	377	237	200	214	150	203	169	114	127	245
Average, all trucks and truck combinations, 1947	126	152	74	109	103	54	57	43	66	35	44	41	76
Average, all trucks and truck combinations, 1946	88	151	80	107	93	39	49	13	50	46	42	44	68
NUMBER PER 1,000 WEIGHING 20,000 POUNDS OR MORE													
Single-unit trucks:													
Panel and pick-up	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2-axle, 4-tired	7	0	0	(1)	0	0	0	0	0	0	0	0	(1)
Other 2-axle, 6-tired	33	28	5	17	3	6	1	0	2	7	4	5	8
Three-axle	44	25	10	18	0	12	9	19	5	0	3	3	7
Average	18	19	3	9	2	3	1	(1)	1	3	3	3	4
Truck combinations:													
Tractor-truck and semitrailer	246	316	120	205	77	79	73	56	70	75	41	51	115
Truck and trailer	0	0	0	0	183	0	2	63	102	13	4	5	34
Average	246	314	120	204	83	79	69	56	72	64	26	35	108
Average, all trucks and truck combinations, 1947	74	93	32	59	36	22	18	15	23	13	9	11	33
Average, all trucks and truck combinations, 1946	50	85	27	51	27	16	13	4	15	16	6	10	26
NUMBER PER 1,000 WEIGHING 22,000 POUNDS OR MORE													
Single-unit trucks:													
Panel and pick-up	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2-axle, 4-tired	7	0	0	1	0	0	0	0	0	0	0	0	(1)
Other 2-axle, 6-tired	19	14	2	9	0	1	(1)	0	(1)	2	2	2	3
Three-axle	4	6	10	8	0	0	9	0	1	0	0	0	3
Average	10	9	2	4	0	(1)	(1)	0	(1)	1	1	1	2
Truck combinations:													
Tractor-truck and semitrailer	150	171	42	100	24	28	17	19	22	31	5	13	48
Truck and trailer	0	0	0	0	48	0	0	16	27	2	1	1	8
Average	150	170	42	100	25	28	16	19	22	26	3	9	45
Average, all trucks and truck combinations, 1947	40	50	12	29	10	9	5	5	7	5	2	3	14
Average, all trucks and truck combinations, 1946	21	42	10	23	6	5	3	1	4	5	[illegible]	3	10

[1] Less than 5 in 10,000.

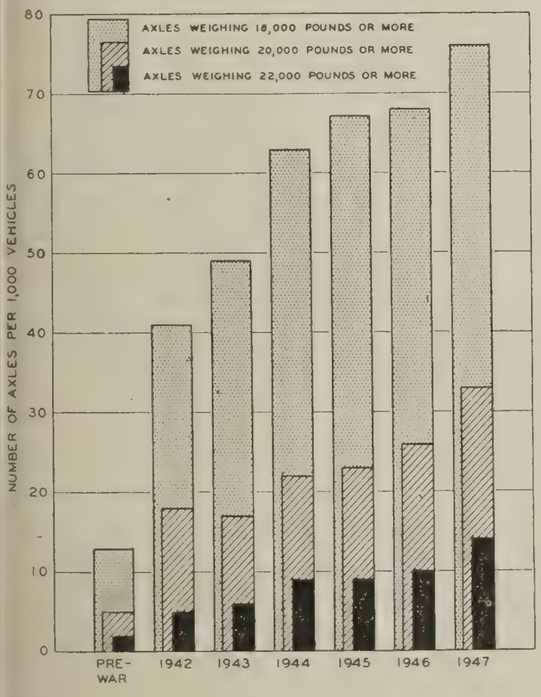

Figure 8.—Number of heavy axle loads per 1,000 trucks and truck combinations (empties included) in the summers of 1942–47 and a prewar year.

Table 12 shows that the high frequency of heavy axle loads in the Middle Atlantic and New England regions, as compared to the Pacific region, was probably not due to differences in enforcement practices. In the Pacific region, 58 of each 1,000 trucks and truck combinations were overloaded, according to State laws, as compared to 41 for the Middle Atlantic and 35 for the New England regions. The number of overloaded truck combinations per 1,000 vehicles of this type was 155 in the Pacific region, 123 in the Middle Atlantic region, and 129 in the New England region. The figures do show, however, that the overloading of truck combinations considerably in excess of legal limits was slightly less common in the Pacific region than in the Middle Atlantic and New England regions. The number of combinations overloaded more than 20 percent above the legal limit per 1,000 vehicles of that type amounted to 16 in the Pacific, 24 in the Middle Atlantic, and 19 in the New England region.

RECOMMENDED WEIGHT LIMITS

Uniform regulations concerning maximum allowable gross weights, axle weights, and axle-group weights have been adopted as a policy by the American Association of State Highway Officials and recommended to the various State governments for adoption.[6] This policy recommends that no axle shall carry a load in excess of 18,000 pounds and no group of axles shall carry a load in excess of amounts specified in a table of permissible weights based on the distance between the extremes of any group of axles.

The data indicate that the recommended axle-load limits are exceeded more frequently than are the other weight limits. In table 13 is shown the number of axles per 1,000 vehicles of various types that exceeded the axle-load limit of 18,000 pounds recommended by the A. A. S. H. O., and the number exceeding these limits by various percentages. This table emphasizes again the high frequency of heavy axle loads in the Middle Atlantic and New England regions.

(Text continued on page 157. Tables 12–15 are on pages 154–155.)

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[6] *Policy concerning maximum dimensions, weights, and speeds of motor vehicles to be operated over the highways of the United States*, adopted April 1, 1946, by the American Association of State Highway Officials; published by the Association, 1946.

Table 12.—*Number of trucks and truck combinations, per 1,000 loaded and empty vehicles, that exceeded the permissible axle, axle-group, or gross-weight laws in effect in the States by various percentages (maximum) of overload, in the summer of 1947*

Region and type of vehicle	Number per 1,000 overloaded	Number per 1,000 overloaded more than—				
		5 percent	10 percent	20 percent	30 percent	50 percent
New England:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	7	---	---	---	---	--
Other 2-axle, 6-tired	19	16	13	6	5	(1)
Three-axle	69	52	43	4	---	--
Average, single-unit trucks	12	10	8	3	3	(1)
Tractor-truck and semitrailer	126	89	59	19	6	1
Truck and trailer	689	689	689	---	---	--
Average, truck combinations	129	92	62	19	6	1
Avg., all trucks and combinations	35	26	19	.6	4	(1)
Middle Atlantic:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	14	10	6	2	1	(1)
Three-axle	89	85	43	26	9	--
Average, single-unit trucks	11	9	5	2	1	(1)
Tractor-truck and semitrailer	124	87	54	24	10	3
Truck and trailer	-----	---	---	---	---	--
Average, truck combinations	123	86	54	24	10	3
Avg., all trucks and combinations	41	29	18	8	3	1
South Atlantic:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	4	3	3	2	(1)	--
Three-axle	34	34	30	25	15	5
Average, single-unit trucks	4	3	3	2	1	(1)
Tractor-truck and semitrailer	186	138	98	39	14	3
Truck and trailer	-----	---	---	---	---	--
Average, truck combinations	185	138	98	39	14	3
Avg., all trucks and combinations	53	39	28	12	4	1
East North Central:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	1	1	1	---	---	--
Three-axle	277	204	158	136	68	--
Average, single-unit trucks	19	14	11	9	11	--
Tractor-truck and semitrailer	177	139	101	51	30	5
Truck and trailer	307	261	220	139	87	23
Average, truck combinations	184	146	108	56	33	6
Avg., all trucks and combinations	77	61	45	26	19	2
East South Central:						
Panel and pick-up	1	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	4	3	1	1	---	--
Three-axle	88	71	60	48	39	36
Average, single-unit trucks	4	3	2	1	1	1
Tractor-truck and semitrailer	122	92	54	25	6	1
Truck and trailer	-----	---	---	---	---	--
Average, truck combinations	122	92	54	25	6	1
Avg., all trucks and combinations	26	20	12	5	2	1
West North Central:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	1	(1)	(1)	(1)	(1)	(1)
Three-axle	59	42	32	9	9	9
Average, single-unit trucks	1	1	(1)	(1)	(1)	(1)
Tractor-truck and semitrailer	183	129	79	30	13	1
Truck and trailer	-----	---	---	---	---	--
Average, truck combinations	173	122	75	28	12	1
Avg., all trucks and combinations	38	27	16	6	3	(1)
West South Central:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	3	2	2	1	---	--
Three-axle	29	18	18	---	---	--
Average, single-unit trucks	2	1	1	(1)	---	--
Tractor-truck and semitrailer	108	83	48	21	8	(1)
Truck and trailer	97	97	85	85	16	8
Average, truck combinations	107	84	50	25	8	(1)
Avg., all trucks and combinations	30	23	14	7	2	(1)
Mountain:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	4	4	3	1	1	--
Three-axle	32	16	3	---	---	--
Average, single-unit trucks	3	2	1	(1)	(1)	--
Tractor-truck and semitrailer	148	105	86	32	11	4
Truck and trailer	134	93	62	16	3	--
Average, truck combinations	146	103	82	29	10	3
Avg., all trucks and combinations	28	20	15	5	2	1
Pacific:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	10	8	6	4	1	--
Three-axle	26	12	12	2	---	--
Average, single-unit trucks	9	5	5	2	(1)	--
Tractor-truck and semitrailer	151	94	57	22	6	2
Truck and trailer	160	94	43	6	1	--
Average, truck combinations	155	94	51	16	4	1
Avg., all trucks and combinations	58	35	20	7	1	(1)
United States average:						
Panel and pick-up	(1)	---	---	---	---	--
Other 2-axle, 4-tired	(1)	---	---	---	---	--
Other 2-axle, 6-tired	5	4	3	1	(1)	(1)
Three-axle	78	57	44	31	16	2
Average, single-unit trucks	7	5	4	2	1	(1)
Tractor-truck and semitrailer	154	113	75	33	14	2
Truck and trailer	159	109	68	30	13	4
Average, truck combinations	154	113	74	33	14	2
Avg., all trucks and combinations	46	34	23	10	4	1

[1] Less than 5 per 10,000.

Table 13.—*Number of axles, per 1,000 loaded and empty trucks and truck combinations, that exceeded the permissible axle-load limit of 18,000 pounds recommended by the A. A. S. H. O. by various percentages of overload, in the summer of 1947*

Region and type of vehicle	Number per 1,000 overloaded	Number per 1,000 overloaded more than—				
		5 percent	10 percent	20 percent	30 percent	50 percent
New England:						
Panel and pick-up	--------	------	------	------	------	----
Other 2-axle, 4-tired	10	------	------	------	------	----
Other 2-axle, 6-tired	39	38	32	20	12	6
Three-axle	91	56	49	8	------	----
Average, single-unit trucks	23	21	18	10	6	3
Tractor-truck and semitrailer	451	371	285	161	72	8
Truck and trailer	--------	------	------	------	------	----
Average, truck combinations	449	369	284	160	72	8
Avg., all trucks and combinations	108	90	71	40	19	4
Middle Atlantic:						
Panel and pick-up	--------	------	------	------	------	----
Other 2-axle, 4-tired	--------	------	------	------	------	----
Other 2-axle, 6-tired	32	29	24	15	6	1
Three-axle	46	34	31	6	------	----
Average, single-unit trucks	19	17	14	8	3	1
Tractor-truck and semitrailer	503	418	327	195	105	25
Truck and trailer	--------	------	------	------	------	----
Average, truck combinations	500	415	325	194	104	25
Avg., all trucks and combinations	146	122	96	57	30	7
South Atlantic:						
Panel and pick-up	--------	------	------	------	------	----
Other 2-axle, 4-tired	--------	------	------	------	------	----
Other 2-axle, 6-tired	5	4	3	2	1	----
Three-axle	15	10	10	10	5	5
Average, single-unit trucks	3	3	2	2	1	(1)
Tractor-truck and semitrailer	259	185	126	45	17	5
Truck and trailer	--------	------	------	------	------	----
Average, truck combinations	258	184	126	45	17	5
Avg., all trucks and combinations	71	52	35	14	5	1
East North Central:						
Panel and pick-up	--------	------	------	------	------	----
Other 2-axle, 4-tired	--------	------	------	------	------	----
Other 2-axle, 6-tired	1	1	1	------	------	----
Three-axle	119	23	23	23	------	----
Average, single-unit trucks	8	2	2	2	------	----
Tractor-truck and semitrailer	199	136	80	26	9	(1)
Truck and trailer	520	347	225	76	18	----
Average, truck combinations	217	148	88	29	10	(1)
Avg., all trucks and combinations	82	54	32	12	4	(1)
East South Central:						
Panel and pick-up	1	------	------	------	------	----
Other 2-axle, 4-tired	--------	------	------	------	------	----
Other 2-axle, 6-tired	4	3	1	1	------	----
Three-axle	18	18	18	9	------	----
Average, single-unit trucks	3	2	1	1	------	----
Tractor-truck and semitrailer	163	114	69	26	5	1
Truck and trailer	--------	------	------	------	------	----
Average, truck combinations	163	114	69	26	5	1
Avg., all trucks and combinations	33	23	14	6	1	(1)
West North Central:						
Panel and pick-up	--------	------	------	------	------	----
Other 2-axle, 4-tired	--------	------	------	------	------	----
Other 2-axle, 6-tired	1	1	(1)	(1)	(1)	----
Three-axle	23	11	9	9	------	----
Average, single-unit trucks	1	1	(1)	(1)	(1)	----
Tractor-truck and semitrailer	207	158	77	23	6	1
Truck and trailer	--------	------	------	------	------	----
Average, truck combinations	196	149	73	22	6	1
Avg., all trucks and combinations	43	33	16	5	1	(1)
West South Central:						
Panel and pick-up	--------	------	------	------	------	----
Other 2-axle, 4-tired	--------	------	------	------	------	----
Other 2-axle, 6-tired	3	2	2	1	------	----
Three-axle	35	35	18	------	------	----
Average, single-unit trucks	2	1	1	(1)	------	----
Tractor-truck and semitrailer	129	98	57	22	7	(1)
Truck and trailer	145	145	56	16	16	8
Average, truck combinations	130	101	57	22	8	(1)
Avg., all trucks and combinations	37	28	16	6	2	(1)
Mountain:						
Panel and pick-up	--------	------	------	------	------	----
Other 2-axle, 4-tired	--------	------	------	------	------	----
Other 2-axle, 6-tired	4	4	3	1	1	----
Three-axle	32	7	2	------	------	----
Average, single-unit trucks	3	2	1	(1)	(1)	----
Tractor-truck and semitrailer	154	108	72	31	13	3
Truck and trailer	80	29	17	3	------	----
Average, truck combinations	142	96	63	27	11	3
Avg., all trucks and combinations	28	19	12	5	2	1
Pacific:						
Panel and pick-up	--------	------	------	------	------	----
Other 2-axle, 4-tired	--------	------	------	------	------	----
Other 2-axle, 6-tired	10	8	6	4	1	----
Three-axle	14	5	1	------	------	----
Average, single-unit trucks	6	4	2	1	(1)	----
Tractor-truck and semitrailer	125	65	37	14	4	1
Truck and trailer	98	39	16	2	------	----
Average, truck combinations	114	55	29	9	2	1
Avg., all trucks and combinations	42	21	11	4	1	(1)
United States average:						
Panel and pick-up	(1)	------	------	------	------	----
Other 2-axle, 4-tired	(1)	------	------	------	------	----
Other 2-axle, 6-tired	9	8	6	4	2	(1)
Three-axle	37	14	11	7	1	1
Average, single-unit trucks	6	5	4	2	1	(1)
Tractor-truck and semitrailer	239	178	119	54	24	5
Truck and trailer	146	84	44	12	4	1
Average, truck combinations	231	169	112	50	22	5
Avg., all trucks and combinations	66	49	33	15	7	1

[1] Less than 5 per 10,000.

Table 14.—*Number of trucks and truck combinations, per 1,000 loaded and empty vehicles, that exceeded the permissible axle-group loads recommended by the A. A. S. H. O. by various percentages of overload, in the summer of 1947*

Region and type of vehicle	Number per 1,000 overloaded	Number per 1,000 overloaded more than—				
		5 percent	10 percent	20 percent	30 percent	50 percent
New England:						
Panel and pick-up	-----	---	---	-----	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	3	(1)	(1)	---	---	--
Three-axle	117	100	44	8	4	--
Average, single-unit trucks	5	3	1	(1)	(1)	--
Tractor-truck and semitrailer	85	52	36	11	5	(1)
Truck and trailer	-----	---	---	---	---	--
Average, truck combinations	85	52	36	11	5	(1)
Avg., all trucks and combinations	21	13	8	2	1	(1)
Middle Atlantic:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	1	(1)	(1)	---	---	--
Three-axle	40	31	24	6	---	--
Average, single-unit trucks	2	1	1	(1)	---	--
Tractor-truck and semitrailer	117	83	63	27	15	5
Truck and trailer	-----	---	---	---	---	--
Average, truck combinations	116	83	63	27	15	5
Avg., all trucks and combinations	32	23	17	7	4	1
South Atlantic:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	-----	---	---	---	---	--
Three-axle	19	15	5	---	---	--
Average, single-unit trucks	1	1	(1)	---	---	--
Tractor-truck and semitrailer	37	25	19	9	3	1
Truck and trailer	-----	---	---	---	---	--
Average, truck combinations	37	25	19	9	3	1
Avg., all trucks and combinations	11	7	5	2	1	(1)
East North Central:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	-----	---	---	---	---	--
Three-axle	-----	---	---	---	---	--
Average, single-unit trucks	-----	---	---	---	---	--
Tractor-truck and semitrailer	99	78	60	27	9	1
Truck and trailer	364	358	283	237	179	63
Average, truck combinations	114	94	73	39	19	5
Avg., all trucks and combinations	40	33	26	14	7	2
East South Central:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	-----	---	---	---	---	--
Three-axle	7	7	---	---	---	--
Average, single-unit trucks	(1)	(1)	---	---	---	--
Tractor-truck and semitrailer	13	9	3	(1)	(1)	--
Truck and trailer	-----	---	---	---	---	--
Average, truck combinations	13	9	3	(1)	(1)	--
Avg., all trucks and combinations	2	2	1	(1)	(1)	--
West North Central:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	(1)	(1)	(1)	(1)	(1)	--
Three-axle	13	11	9	9	9	--
Average, single-unit trucks	(1)	(1)	(1)	(1)	(1)	--
Tractor-truck and semitrailer	74	50	34	16	5	(1)
Truck and trailer	-----	---	---	---	---	--
Average, truck combinations	70	47	32	15	5	(1)
Avg., all trucks and combinations	15	10	7	3	1	(1)
West South Central:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	-----	---	---	---	---	--
Three-axle	12	---	---	---	---	--
Average, single-unit trucks	(1)	---	---	---	---	--
Tractor-truck and semitrailer	19	13	8	4	1	(1)
Truck and trailer	32	32	32	32	32	16
Average, truck combinations	20	14	9	6	3	1
Avg., all trucks and combinations	5	4	2	2	1	(1)
Mountain:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	-----	---	---	---	---	--
Three-axle	10	9	5	---	---	--
Average, single-unit trucks	(1)	(1)	(1)	---	---	--
Tractor-truck and semitrailer	78	65	46	22	10	1
Truck and trailer	125	99	68	20	---	--
Average, truck combinations	85	70	49	22	8	1
Avg., all trucks and combinations	15	12	9	4	1	(1)
Pacific:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	-----	---	---	---	---	--
Three-axle	14	13	5	---	---	--
Average, single-unit trucks	3	3	1	---	---	--
Tractor-truck and semitrailer	187	143	103	33	13	3
Truck and trailer	242	173	77	12	1	--
Average, truck combinations	209	155	93	25	8	2
Avg., all trucks and combinations	72	54	32	8	3	1
United States average:						
Panel and pick-up	-----	---	---	---	---	--
Other 2-axle, 4-tired	-----	---	---	---	---	--
Other 2-axle, 6-tired	(1)	(1)	(1)	(1)	(1)	--
Three-axle	17	14	7	1	(1)	--
Average, single-unit trucks	1	1	(1)	(1)	(1)	--
Tractor-truck and semitrailer	77	57	42	17	7	1
Truck and trailer	209	163	91	42	26	9
Average, truck combinations	89	67	46	19	9	2
Avg., all trucks and combinations	25	19	12	5	2	1

[1] Less than 5 per 10,000.

Table 15.—*Number of trucks and truck combinations, per 1,000 loaded and empty vehicles, that exceeded the permissible motor-vehicle loads recommended by the A. A. S. H. O. by various percentages (maximum) of overload, in the summer of 1947*

Region and type of vehicle	Number per 1,000 overloaded	Number per 1,000 overloaded more than—				
		5 percent	10 percent	20 percent	30 percent	50 percent
New England:						
Panel and pick-up	---	---	---	---	---	---
Other 2-axle, 4-tired	10	---	---	---	---	---
Other 2-axle, 6-tired	39	38	32	20	12	6
Three-axle	137	105	62	8	4	---
Average, single-unit trucks	24	22	18	10	6	3
Tractor-truck and semitrailer	300	252	198	120	56	7
Truck and trailer	---	---	---	---	---	---
Average, truck combinations	299	251	197	119	56	7
Avg., all trucks and combinations	79	68	54	32	16	4
Middle Atlantic:						
Panel and pick-up	---	---	---	---	---	---
Other 2-axle, 4-tired	---	---	---	---	---	---
Other 2-axle, 6-tired	32	29	24	15	6	1
Three-axle	56	53	44	6	---	---
Average, single-unit trucks	19	18	15	8	3	1
Tractor-truck and semitrailer	328	277	225	142	80	22
Truck and trailer	---	---	---	---	---	---
Average, truck combinations	326	275	224	141	80	22
Avg., all trucks and combinations	100	86	70	43	23	7
South Atlantic:						
Panel and pick-up	---	---	---	---	---	---
Other 2-axle, 4-tired	---	---	---	---	---	---
Other 2-axle, 6-tired	5	4	3	2	1	---
Three-axle	24	20	10	10	5	5
Average, single-unit trucks	4	3	2	2	1	(1)
Tractor-truck and semitrailer	199	147	108	45	18	5
Truck and trailer	---	---	---	---	---	---
Average, truck combinations	198	147	108	45	18	5
Avg., all trucks and combinations	56	42	30	14	6	1
East North Central:						
Panel and pick-up	---	---	---	---	---	---
Other 2-axle, 4-tired	---	---	---	---	---	---
Other 2-axle, 6-tired	1	1	1	---	---	---
Three-axle	142	23	23	23	---	---
Average, single-unit trucks	10	2	2	2	---	---
Tractor-truck and semitrailer	184	137	102	41	15	1
Truck and trailer	369	358	283	237	179	52
Average, truck combinations	195	150	112	52	24	4
Avg., all trucks and combinations	75	54	41	20	8	1
East South Central:						
Panel and pick-up	1	---	---	---	---	---
Other 2-axle, 4-tired	---	---	---	---	---	---
Other 2-axle, 6-tired	4	3	1	1	---	---
Three-axle	34	31	18	9	---	---
Average, single-unit trucks	3	2	1	1	---	---
Tractor-truck and semitrailer	122	91	56	22	4	1
Truck and trailer	---	---	---	---	---	---
Average, truck combinations	122	91	56	22	4	1
Avg., all trucks and combinations	25	19	11	5	1	(1)
West North Central:						
Panel and pick-up	---	---	---	---	---	---
Other 2-axle, 4-tired	---	---	---	---	---	---
Other 2-axle, 6-tired	1	(1)	(1)	(1)	(1)	---
Three-axle	32	27	25	9	9	---
Average, single-unit trucks	1	(1)	(1)	(1)	(1)	---
Tractor-truck and semitrailer	175	125	76	26	8	1
Truck and trailer	---	---	---	---	---	---
Average, truck combinations	165	118	72	25	8	1
Avg., all trucks and combinations	36	25	16	5	2	(1)
West South Central:						
Panel and pick-up	---	---	---	---	---	---
Other 2-axle, 4-tired	---	---	---	---	---	---
Other 2-axle, 6-tired	3	2	2	1	---	---
Three-axle	29	18	18	18	---	---
Average, single-unit trucks	2	1	1	1	---	---
Tractor-truck and semitrailer	100	79	45	21	7	1
Truck and trailer	97	97	32	32	32	16
Average, truck combinations	100	80	44	22	9	2
Avg., all trucks and combinations	28	22	13	7	2	1
Mountain:						
Panel and pick-up	---	---	---	---	---	---
Other 2-axle, 4-tired	---	---	---	---	---	---
Other 2-axle, 6-tired	4	4	3	1	1	---
Three-axle	30	14	5	---	---	---
Average, single-unit trucks	2	2	1	(1)	(1)	---
Tractor-truck and semitrailer	157	119	86	41	17	4
Truck and trailer	161	136	98	28	---	---
Average, truck combinations	158	122	88	39	14	3
Avg., all trucks and combinations	30	23	16	7	2	1
Pacific:						
Panel and pick-up	---	---	---	---	---	---
Other 2-axle, 4-tired	---	---	---	---	---	---
Other 2-axle, 6-tired	10	8	6	4	1	---
Three-axle	17	13	6	---	---	---
Average, single-unit trucks	7	5	3	1	(1)	---
Tractor-truck and semitrailer	217	164	117	39	14	3
Truck and trailer	300	196	90	14	1	---
Average, truck combinations	250	177	106	29	9	2
Avg., all trucks and combinations	88	63	38	10	3	1
United States average:						
Panel and pick-up	(1)	---	---	---	---	---
Other 2-axle, 4-tired	(1)	---	---	---	---	---
Other 2-axle, 6-tired	9	7	6	4	2	(1)
Three-axle	46	23	15	7	1	1
Average, single-unit trucks	7	5	4	2	1	(1)
Tractor-truck and semitrailer	195	151	110	52	23	5
Truck and trailer	255	187	102	43	26	8
Average, truck combinations	200	154	109	51	23	5
Avg., all trucks and combinations	59	45	32	15	7	1

[1] Less than 5 per 10,000.

Trends in Motor-Vehicle Travel, 1947

BY THE DIVISION OF FINANCIAL AND ADMINISTRATIVE RESEARCH
PUBLIC ROADS ADMINISTRATION

Reported by G. P. St. CLAIR, Chief of Division

Total travel of motor vehicles in 1947 is estimated as 371 billion vehicle-miles, of which 187 billion was on rural highways and 184 billion on urban roads and streets. Passenger cars accounted for more than 300 billion vehicle-miles of the total, busses 4 billion, and trucks and combinations 66 billion. In every category these totals were greater than in any previous year. Total travel in 1947 exceeded that of 1946 by 9 percent and was 11 percent more than in 1941. The increase in travel of trucks and combinations was more than twice that of passenger cars, the former rising in 1947 to 18 percent above 1946, the latter 7 percent.

The average vehicle traveled 9,831 miles in 1947, using 746 gallons of gasoline at a rate of 13.19 miles per gallon. After the wartime decline, average annual automobile travel rose in 1946 to 7 percent more than the 1941 level, but in 1947 dropped back to 5 percent above 1941. Average annual truck travel, while showing a steady recovery, had in 1947 only reached 93 percent of the 1941 level.

In addition to the 1947 data, this article reports estimated total motor-vehicle travel in the United States for the years 1921–47, with a segregation between rural and urban traffic from 1929 on. In these 26 years, total annual travel has risen from 55 billion to 371 billion vehicle-miles, an increase of 574 percent. Rural travel has gradually risen in proportion from 46 to 50 percent of the total.

Although a respectable body of current data underlies the annual travel estimates, it is still necessary to base them fundamentally on the patterns determined by the comprehensive traffic surveys made circa 1936. As the base period becomes more remote the hazards of this procedure increase. A new set of comprehensive surveys is needed to provide a better foundation for the many problems in highway planning, construction, and operation that lie ahead.

THE SERIES of classified estimates of motor-vehicle travel in the United States reported in two previous articles in PUBLIC ROADS [1] is carried forward in this article for the year 1947. The procedures used in making these estimates were the same as those described in the two previous reports, the principal factors controlling the calculations being (1) the annual estimates of rural-road traffic described in another article in this issue of PUBLIC ROADS; (2) the annual reports of highway use of motor fuel; and (3) reported motor-vehicle registrations. As in the previous calculations, the 1947 estimates were based on indicated changes from a previous year, the year 1946 being used as the base year in this instance.

Table 1 reports, for the various classes of motor vehicles, the estimates for 1947 of rural, urban, and total vehicle-miles traveled, average miles traveled and motor fuel consumed per vehicle, and average travel per gallon of motor fuel consumed. The numbers of registered vehicles, as modified for the purpose of these estimates, are also given. The total travel of motor vehicles in 1947 is estimated as 371 billion vehicle-miles, of which 187 billion were traveled on rural highways and 184 billion on urban highways and streets. Passenger cars traveled approximately 300 billion vehicle-miles, busses over 4 billion, and trucks and combinations 66 billion. For all vehicle types and for both rural and urban travel, these totals were greater than in any previous year.

Table 2 gives a comparison of the 1947 vehicle-mile estimates with those for 1941 and 1946. Total travel in 1947 was 11.2 percent greater than in 1941, the maximum prewar year, and was 8.8 percent greater than in 1946.

The relative increase of rural travel in 1947 over that of 1946 was slightly greater than that of urban travel. A similar but much greater contrast observed in the comparison of the 1946 with the 1945 estimates [1] was attributed to the recovery from the restrictions of the war years, during which rural travel suffered much greater reductions than did urban travel. The two successive comparisons (expressed in percent) are as follows:

	1946 over 1945	*1947 over 1946*
Increase of rural travel	43. 2	9. 3
Increase of urban travel	31. 1	8. 3

In the comparison with 1941 values table 2 shows that the relative increase in urban travel, 12.5 percent, was greater than that in rural travel, which was 9.9 percent. A later section of this report deals with the trends, over a period of years, in the relation between rural and urban travel.

Both comparisons given in table 2 indicate that the relative increase in the travel of trucks

Table 1.—*Classified estimate of motor-vehicle travel in the United States in the calendar year 1947*

Vehicle type	Motor-vehicle travel			Number of registered vehicles [1]	Average travel per vehicle	Motor-fuel consumption		Average travel per gallon of fuel consumed
	Rural travel	Urban travel	Total travel			Total [2]	Average per vehicle	
	Million vehicle-miles	*Million vehicle-miles*	*Million vehicle-miles*	*Thousands*	*Miles*	*Million gallons*	*Gallons*	*Miles*
Passenger vehicles:								
Passenger cars [3]	143, 662	156, 620	300, 282	30, 872	9, 727	20, 086	651	14. 95
Busses:								
Commercial	1, 480	2, 080	3, 560	89	40, 000	712	8, 000	5. 00
School and nonrevenue	621	70	691	87	7, 989	66	770	10. 37
All busses	2, 101	2, 150	4, 251	176	24, 221	778	4, 436	5. 46
All passenger vehicles	145, 763	158, 770	304, 533	31, 048	9, 809	20, 864	672	14. 60
Trucks and combinations	40, 771	25, 318	66, 089	6, 650	9, 939	7, 243	1, 089	9. 13
All motor vehicles	186, 534	184, 088	370, 622	37, 698	9, 831	28, 107	746	13. 19

[1] These registration totals differ from those given in Public Roads Administration table MV–1 for 1947 because of the following adjustments: (1) Approximate correction for defective classification in 4 States, as described in footnotes 9, 10, 13, and 14 of that table; (2) inclusion of publicly owned vehicles, listed separately in table MV–1; (3) reduction of private and commercial truck registrations by 2.5 percent to allow for registrations in more than 1 State; and (4) substitution of bus totals as estimated by the bus industry to afford a complete segregation of commercial busses from school and nonrevenue busses and to allow for duplication because of registrations in more than 1 State.

[2] Total highway use of motor fuel in 1947 is given as 28,216 million gallons in Public Roads Administration table G–21. For this analysis there was deducted from that total 109 million gallons estimated use by motorcycles (250 gallons per motorcycle).

[3] Including taxicabs.

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[1] *Trends in motor-vehicle travel, 1936 to 1945*, PUBLIC ROADS, vol. 24, No. 10, Oct.-Nov.-Dec. 1946, and *Trends in motor-vehicle travel, 1946*, PUBLIC ROADS, vol. 25, No. 3, March 1948.

Table 2.—*Increase in motor-vehicle travel, 1947 compared with 1941 and 1946*

Vehicle type	Percentage increase of travel—					
	1947 over 1941			1947 over 1946		
	Rural	Urban	Total	Rural	Urban	Total
Passenger vehicles [1]	7.7	10.9	9.3	7.2	6.9	7.0
Trucks and combinations	18.5	23.6	20.4	17.9	17.5	17.7
All motor vehicles	9.9	12.5	11.2	9.3	8.3	8.8

[1] Includes both passenger cars and busses.

and combinations has been more than twice that of passenger vehicles. The estimated travel of trucks and combinations in 1947 was 20.4 percent more than their travel in 1941, and 17.7 percent in excess of their 1946 travel; the corresponding figures for passenger vehicles being 9.3 and 7.0 percent, respectively. This remarkable increase in truck traffic undoubtedly reflects the sustained and increasing volume of business activity in the postwar years. Reference to the article *Traffic Trends on Rural Roads in 1947*, also published in this issue, will reveal the fact that the ton-miles of freight operation on main roads has increased even more rapidly than the vehicle-miles of truck travel.[2]

AVERAGE ANNUAL MILEAGES

Further comparisons of the travel characteristics of passenger cars and trucks are given in figure 1 and table 3. Figure 1 compares the average miles per year traveled by passenger cars, as given by these annual estimates, with the corresponding values for trucks and combinations. It will be observed that, for the period from 1936 to 1941, the average annual mileages of trucks and combinations were well above those of passenger cars, and that for both vehicle types the values were increasing at rather steady rates from year to year. As a result of gasoline rationing and other restrictions during the war period, the average annual mileages of both vehicle types fell off sharply. Because of the necessities of wartime freight transportation, the restrictions on passenger cars were much more severe than those on trucks; and the average mileage of passenger cars fell off to about 6,200 miles per year in 1943, whereas the average for trucks fell only slightly below 9,000 miles in the minimum year, 1944.

The trends during the postwar years appear to have been very different. The average mileage of passenger cars recovered very sharply in 1945 and 1946; the value for the latter year being nearly 10,000 miles per vehicle, a figure considerably in excess of the prewar averages. In 1947 the value fell to 9,727 miles per vehicle. In the case of trucks and combinations, there has been a steady recovery, but the 1947 value, 9,939 miles per vehicle, is considerably below that of 10,739 miles in 1941 and slightly below that for 1936.

Some light on the peculiarities displayed in figure 1 may be obtained by an examination of the data set forth in table 3, which gives for passenger cars and for trucks and combinations the total vehicle-miles traveled, numbers registered, and average miles per vehicle for the years 1936–47. Each of these quantities is indexed against its value for the year 1941.

Turning first to passenger cars, we find that the total travel of these vehicles in 1947 was 8.9 percent above the 1941 value. The number registered, however, was only 4 percent above 1941. The tremendous unsatisfied demand for passenger automobiles is a matter of common knowledge. Among the causes for this great demand, two principal factors can be discerned. First, the abnormal age distribution of passenger cars resulting from the wartime cessation of production has produced a very large need for replacements. Second, the great rise in national income, and the penetration of relatively high incomes among what were formerly low-income groups in the labor and farm population has greatly broadened the base for the purchase of new and used passenger cars. Automobile production was slow in gaining headway during the first two postwar years, and only in 1948 has anything approaching a maximum production rate been reached. In the face of great demand and short supply it is natural that the passenger cars on hand should be overworked, so to speak, with a resulting increase of average passenger-car mileage to values well above those of the prewar years.

Evidence that this effect was somewhat diminished in 1947 is found in the fact that the estimated average annual mileage of these vehicles dropped from 9,942 miles in 1946 to 9,727 miles in 1947. This drop may be partially explained by the fact that a greater number of vehicles were driven less than 12 months in 1947 than were so driven in 1946. This fact becomes obvious when it is pointed out that there were more than 3 million new passenger-car registrations in 1947, whereas there were approximately 1.8 million in 1946.[3] It is probable, however, that with a materially increased supply of passenger cars in 1947, the tendency to drive the average car a greater than normal mileage had begun to diminish. It is not unlikely that the trend toward somewhat decreased average annual mileage of passenger cars will continue for a year or two as a result of the greatly increased production of these vehicles.

The data for trucks indicate a very different situation. It is shown in table 3 that the travel of trucks and combinations in 1947 was 20.4 percent above the 1941 value. The

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[2] See figures 4, 5, and 6 of above-cited article, and text, pp. 148–152.

[3] New passenger-car registrations, as reported by R. L. Polk and Company, and quoted in the Automobile Manufacturers Association publication *Automobile Facts and Figures*, 1948 edition, p. 13, were 1,815,196 in 1946 and 3,167,231 in 1947.

Table 3.—*Comparison of total vehicle-miles, registrations, and average miles per vehicle, for passenger cars and for trucks and combinations, 1936–47*

Year	Passenger cars						Trucks and combinations					
	Estimate of total vehicle-miles traveled [1]		Number registered [1]		Average miles per vehicle [1]		Estimate of total vehicle-miles traveled [1]		Number registered [1]		Average miles per vehicle [1]	
	Amount	Index on 1941 value	Amount	Index on 1941 value	Amount	Index on 1941 value	Amount	Index on 1941 value	Amount	Index on 1941 value	Amount	Index on 1941 value
	Millions		*Thousands*				*Millions*		*Thousands*			
1936	208,654	75.7	24,201	81.5	8,622	92.9	41,107	74.9	4,071	79.6	10,098	94.0
1937	223,467	81.1	25,490	85.9	8,767	94.4	44,151	80.4	4,301	84.1	10,264	95.6
1938	224,174	81.3	25,272	85.1	8,871	95.5	44,495	81.1	4,285	83.8	10,383	96.7
1939	235,629	85.5	26,252	88.4	8,976	96.7	47,219	86.0	4,495	87.9	10.504	97.8
1940	249,559	90.5	27,488	92.6	9,079	97.8	49,927	91.0	4,699	91.9	10,624	98.9
1941	275,685	100.0	29,691	100.0	9,285	100.0	54,891	100.0	5,112	100.0	10,739	100.0
1942	218,239	79.2	27,970	94.2	7,803	84.0	45,727	83.3	4,762	93.2	9.602	89.4
1943	161,788	58.7	26,005	87.6	6,221	67.0	41,594	75.8	4,611	90.2	9,021	84.0
1944	166,073	60.2	25,562	86.1	6,497	70.0	41,708	76.0	4,642	90.8	8,984	83.7
1945	199,185	72.3	25,789	86.9	7,724	83.2	45,909	83.6	4,956	96.9	9,264	86.3
1946	280,457	101.7	28,209	95.0	9,942	107.1	56,146	102.3	5,839	114.2	9,615	89.5
1947	300,282	108.9	30,872	104.0	9,727	104.8	66,089	120.4	6,650	130.1	9,939	92.6

[1] Values as given in *Trends in motor-vehicle travel, 1936 to 1945*, Public Roads, Oct.-Nov.-Dec. 1946; *Trends in motor-vehicle travel, 1946*, Public Roads, March 1948; and in table 1 of this article.

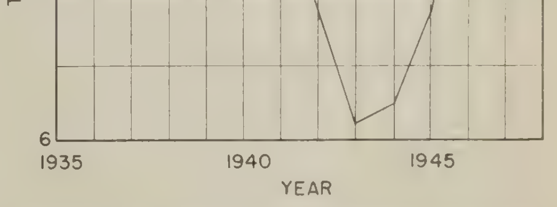

Figure 1.—Trends in the average miles per vehicle traveled by passenger cars and by trucks and combinations.

number registered, on the other hand, was 30.1 percent above 1941. In contrast to the case of passenger cars, we find the supply of trucks, as evidenced by registrations, showing a greater relative increase than the demand for truck transportation as evidenced by vehicle-miles traveled. Although the truck-production figures indicate a continuing healthy demand for freight vehicles, it is quite evident that the shortage of supply is by no means as acute as in the case of passenger cars. It should be borne in mind that the increase in truck travel over 1941 values was more than twice the increase in passenger-car travel, and that, in terms of ton-miles of operation, the increase was even greater. In spite of these great increases, the rise in truck registrations was such that the large volume of increased business could be carried at an average mileage per vehicle lower than that of the prewar years. It is probable also that a considerable part of the increased truck registrations include those of farmers, small business men, and trucking operators new to the field, all of whom would have a tendency toward low-mileage operation.

Although the explanations given above tend to confirm the comparisons given in figure 1 and table 3, there may be some disposition to question whether the accuracy of the estimates is such as to make these findings entirely acceptable. It must be acknowledged that insufficient data are available to produce estimates which could be accepted as highly accurate. It is necessary to use certain procedures and certain assumptions that are not fully supported, and to carry forward trends from year to year which may involve the continuation of past inaccuracies. It is found, however, that where options exist in making the estimates, they do not lead to large deviations in the final results. If an arbitrary adjustment is attempted in order to eliminate an apparent inconsistency in one item, compensating adjustments in other items will produce greater inconsistencies than the one it is desired to remove. Although uncertainties as to the accuracy of the estimates must continue to exist until more adequate data are available, it is believed the findings are reasonably consistent and in harmony with discernible trends.

VEHICLE-MILE ESTIMATES, 1921–47

In table 4 there are given values of the estimated total motor-vehicle travel in the United States for the years 1921–47. A segregation of these values between rural and urban traffic is given for the years 1929–47. Values from 1936 through 1946 were given in the two Public Roads articles previously referred to.[4] The values for the earlier years have been given some currency but have not previously been published.

Because of the fact that comprehensive studies of traffic and motor-vehicle use were not made prior to the State-wide highway planning survey period, for which 1936 is generally taken as the base year, it is not possible at this late date to make accurate estimates of motor-vehicle travel for years prior to 1936. Estimates of total travel given in table 4 were obtained by applying to the values of total highway use of motor fuel given in the annual motor-fuel usage analysis (Public Roads Administration table G–21) the value of 13.984 miles per gallon, derived from the vehicle-mile estimates for the year 1936. Although this procedure is open to question, there exists no volume of data whereby an accurate trend in the variation of average miles per gallon for those earlier years could be developed. The values given in table 4 are without doubt sufficiently accurate for the purposes for which estimates of vehicle-miles traveled in years prior to 1936 are needed.

The values of rural and urban travel given in table 4 were derived by extending backward to 1929 the trend in percentage relation of rural travel to total travel indicated by the analysis which led to the estimates of vehicle-miles for the years 1936–41. Such a procedure is also of questionable accuracy; and it was felt that this estimated segregation between rural and urban travel should not be carried to years earlier than 1929. No classification of these earlier estimates by type of vehicle has been made. Reasonable values for a few years prior to 1936 could probably be estimated, but it is felt that no very useful purpose would be served by making such estimates. The trend curves for total travel from 1921 through 1947 and for rural and urban travel from 1929 through 1947 are given in figure 2.

COMPARISON OF TRENDS IN MOTOR-FUEL USE AND RURAL HIGHWAY TRAVEL

Table 4 gives, for each year from 1929 through 1947, the percentage distribution between rural and urban travel. These values indicate a steadily increasing proportion of rural travel to total travel from 1929 through 1941. The question may be raised whether this indication reflects the findings of actual data or whether assumptions have been made in annual estimates which have produced an artificial trend not confirmed by facts. The comparisons given in table 5 and illustrated in figure 3 throw some light on this question.

Table 5 gives, for the years 1929–47, the Nation-wide totals of highway use of motor fuel. These values are also expressed in the form of an index and compared with the cor-

Table 4.—*Estimate of motor-vehicle travel in the United States, 1921–47* [1]

Year	Rural		Urban		Total	
	Amount	Percentage	Amount	Percentage	Amount	Percentage
	Million vehicle-miles		*Million vehicle-miles*		*Million vehicle-miles*	
1921	---------	--------	---------	--------	55,027	---------
1922	---------	--------	---------	--------	67,697	---------
1923	---------	--------	---------	--------	84,995	---------
1924	---------	--------	---------	--------	104,838	---------
1925	---------	--------	---------	--------	122,346	---------
1926	---------	--------	---------	--------	140,735	---------
1927	---------	--------	---------	--------	158,453	---------
1928	---------	--------	---------	--------	172,856	---------
1929	90,311	45.7	107,409	54.3	197,720	100.0
1930	95,118	46.1	111,202	53.9	206,320	100.0
1931	100,571	46.5	115,580	53.5	216,151	100.0
1932	94,151	47.0	106,366	53.0	200,517	100.0
1933	95,064	47.4	105,578	52.6	200,642	100.0
1934	103,050	47.8	112,513	52.2	215,563	100.0
1935	110,241	48.2	118,327	51.8	228,568	100.0
1936	122,678	48.7	129,450	51.3	252,128	100.0
1937	132,038	48.9	138,072	51.1	270,110	100.0
1938	134,913	49.8	136,264	50.2	271,177	100.0
1939	143,149	50.2	142,253	49.8	285,402	100.0
1940	152,150	50.4	149,993	49.6	302,143	100.0
1941	169,805	50.9	163,591	49.1	333,396	100.0
1942	128,861	48.2	138,235	51.8	267,096	100.0
1943	97,757	47.3	108,990	52.7	206,747	100.0
1944	100,830	47.7	110,750	52.3	211,580	100.0
1915	119,183	47.9	129,743	52.1	248,926	100.0
1946	170,606	50.1	170,049	49.9	340,655	100.0
1947	186,534	50.3	184,088	49.7	370,622	100.0

[1] For years prior to 1936 values of total motor-vehicle travel were extrapolated with the aid of motor-fuel consumption data, by assuming a constant value for average miles per gallon, e. g., 13.984 miles per gallon, the value derived in making the estimate for 1936.

Table 5.—*Comparison of trends in highway use of motor fuel and rural highway travel, 1929–47*

Year	Highway use of motor fuel [1]	Indexes relative to 1936 values	
		Highway use of motor fuel	Rural highway travel [2]
	Million gallons		
1929	14,139	78.1	73.6
1930	14,754	81.5	77.5
1931	15,457	85.4	82.0
1932	14,339	79.2	76.7
1933	14,348	79.3	77.5
1934	15,415	85.2	84.0
1935	16,345	90.3	89.9
1936	18,099	100.0	100.0
1937	19,455	107.5	107.6
1938	19,612	108.4	110.0
1939	20,714	114.4	116.7
1940	22,001	121.6	124.0
1941	24,192	133.7	138.4
1942	19,940	110.2	105.0
1943	16,004	88.4	79.7
1944	16,430	90.8	82.2
1945	19,149	105.8	97.2
1946	25,649	141.7	139.1
1947	28,216	155.9	152.1

[1] See *Highway Statistics, Summary to 1945*, Public Roads Administration, 1947, p. 5; and table G–21, 1947.
[2] Derived from table 4, second column.

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[4] See footnote 1, p. 156.

responding index of the volume of rural travel, calculated from the data given in table 4. The index values are based on the year 1936, which is the year with which the annual vehicle-mile estimates began, and is generally taken as the base year of the comprehensive planning-survey studies. Both sets of indexes are plotted in the upper panel of figure 3. It will be observed that, for the years 1937–41, there is a gradual upward divergence of the rural travel index from that of total highway use of motor fuel. In other words, the slope of the rural traffic line is appreciably steeper than the slope of the motor-fuel consumption line.

These two sets of index values were derived from entirely independent data. The rural travel estimates are taken without change from the annual calculations of rural travel based chiefly on the fixed automatic recorder data. The values for total highway use of motor fuel are obtained by an analysis of the reports of motor-fuel consumption submitted by the several States. The motor-fuel data can be taken as representative of total motor-vehicle travel, both rural and urban. This being the case, the increase of the rural-travel index relative to the motor-fuel-use index during the period 1931–41 is a definite indication that the percentage relation of rural travel to total travel was rising during these years.

The objection might be raised that changes in average miles per gallon, as between rural and urban use of motor vehicles, could account for the difference in the two trend lines. The loadometer studies on main rural roads indicate that the gross loads and carried loads of trucks and combinations increased materially during the period under study; but this factor, rather than accounting for the difference in trends, would work in the opposite direction, since it would imply an increase in motor-fuel consumption on rural roads, relative to the total volume of rural travel.

This positive indication for the period 1936–41 lends support to the extrapolated values for rural travel prior to 1936, which carry backward the same trend. Index values for the two graphs in figure 3 cross at the year 1936, but the steeper slope of the index of rural highway travel is plainly evident. The percentage relations of rural travel to total travel are shown graphically in the lower panel of figure 3 and they indicate a gradual but steady rise in the relative amount of rural travel from 1929 through 1941.

The indicated trend in the relation of rural to urban travel is consistent with the generally known facts of highway and motor-vehicle history. In the early days of the motor vehicle its ownership and use was confined largely to the cities and their immediate surroundings. As the network of improved rural roads gradually developed, rural ownership increased and the radius of operation of urban vehicles was greatly enlarged, with the result that the volume of rural travel began gradually to overtake that of urban travel. The planning-survey road-use studies, conducted in a large number of States during the period 1935–39, indicated a Nation-wide distribution of somewhat more than 50 percent rural travel.

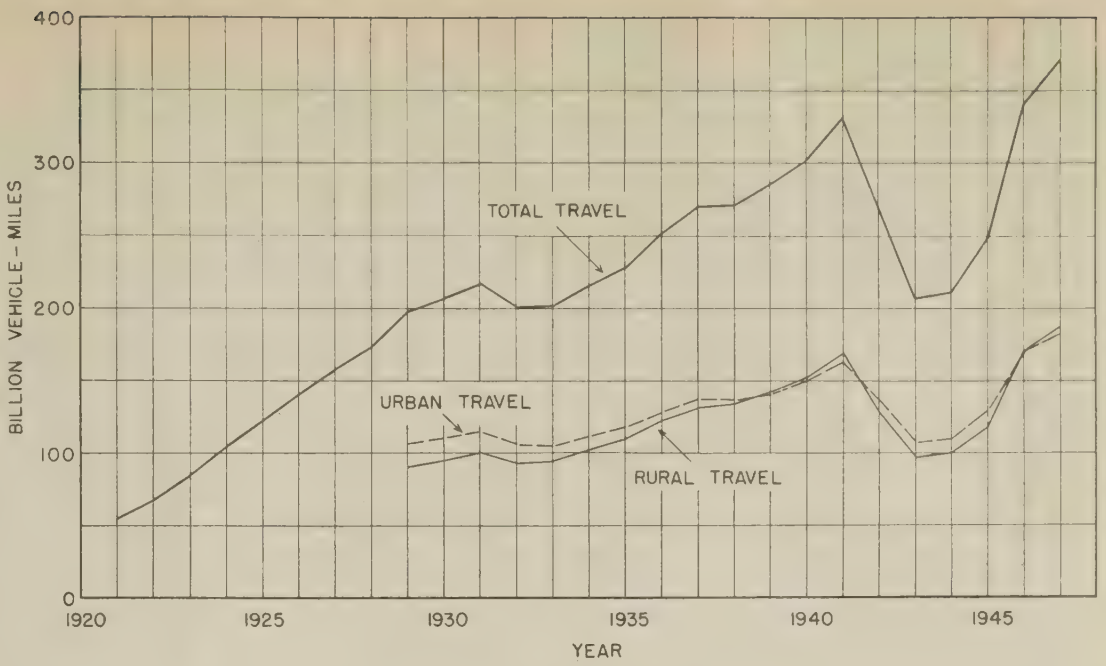

Figure 2.—Estimated total motor-vehicle travel, 1921–47; estimated rural and urban travel, 1929–47.

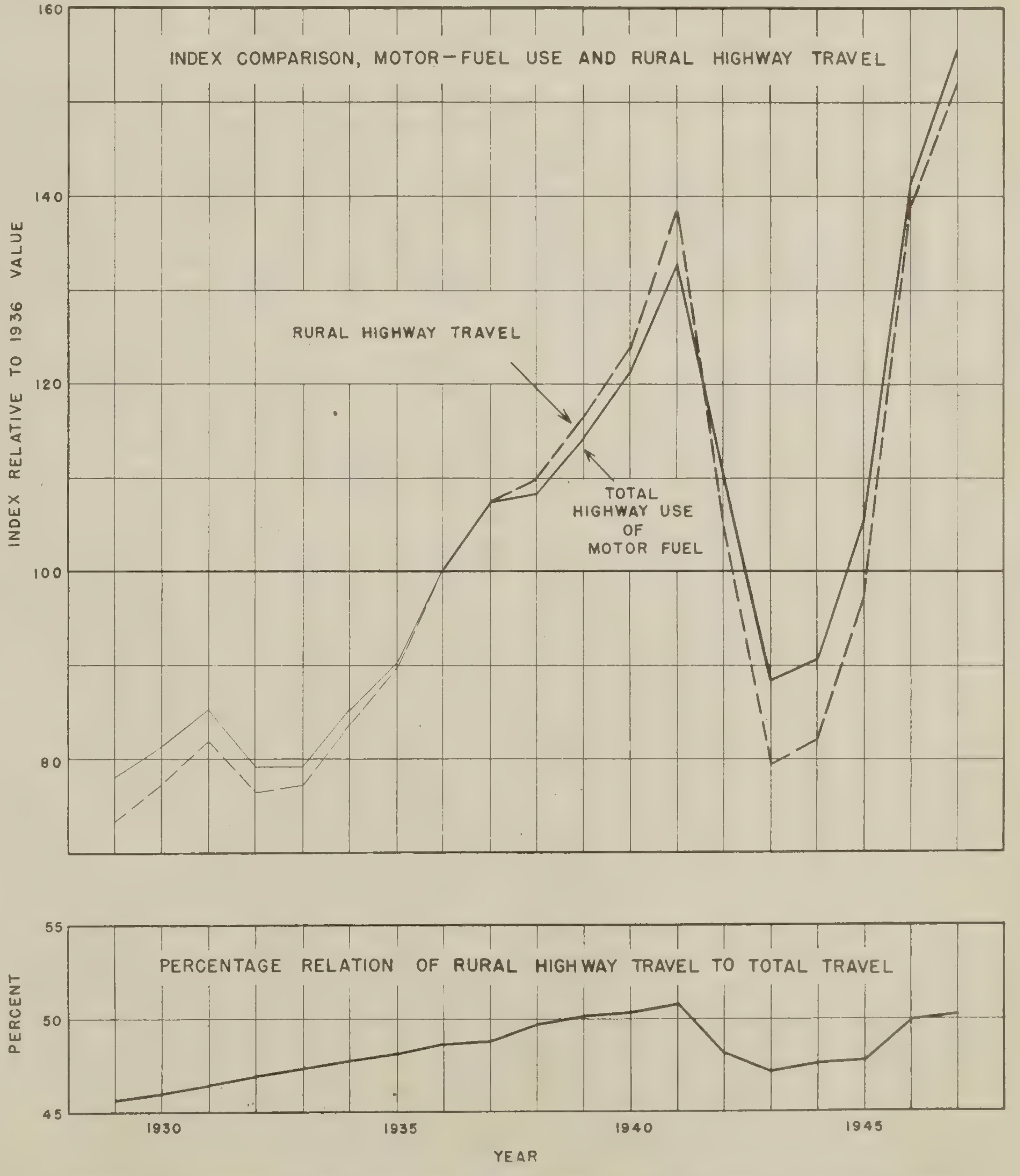

Figure 3.—Trends in total highway use of motor fuel and rural highway travel.

The basic calculations for the annual vehicle-mile estimates, which depended more heavily upon the motor-vehicle-allocation and traffic studies than upon the road-use data, indicated slightly less than 50 percent rural travel in 1936, with the value reaching 50 percent for the first time in 1939.

As may be observed in figure 2, the decline in rural travel during the war period was much more severe than that in urban travel. This situation is reflected in figure 3 by the crossing of the index lines, the motor-fuel consumption index for the years 1942–45 being considerably above the index of rural travel. In the years 1946 and 1947 the recovery of the two indexes has been along more or less parallel lines, but it is shown in the lower panel of figure 3 that the percentage of rural travel, although slightly greater than 50 percent in 1946 and 1947, had not yet quite recovered to its prewar value. Whether it will do so in the next few years is conjectural. Purely from the standpoint of a return to normal trends such a result might be expected. On the other hand, there may have been permanent changes in the relative urbanization of the population which would tend to work against such a development. Furthermore, the current movement toward the relief of urban congestion may have the effect of causing a material increase of urban travel relative to total travel.

MORE ACCURATE AND COMPLETE DATA NEEDED

The making of annual Nation-wide estimates of motor-vehicle travel has proved to be a useful activity, well worth continuing. The value of these estimates would be greatly enhanced if it were possible to subdivide the Nation-wide totals and averages into values for each State. Although vehicle-mile estimates are frequently made in individual States, it has not yet been found feasible to organize a procedure whereby each State highway department would make and report such estimates annually.

Great difficulties attend the calculation of classified vehicle-mile estimates in an individual State. The Nation-wide rural traffic analysis is based primarily on reports from about 660 continuous automatic recorders, an average of about 14 per State. This is a rather slender sample on which to base an estimate of total vehicle-miles, even though reinforced by data from portable recorders, manual counts, and other sources. In calculating averages per vehicle difficulties are encountered in making allowances for the out-of-State travel of vehicles registered in the State and the travel within the State of vehicles from other States. In making use of motor-fuel consumption statistics similar allowances must be made for motor fuel purchased in one State and used in another. These obstacles are not insurmountable, but they introduce sources of inaccuracy to which the calculation of Nation-wide estimates is not subject.

Although a respectable body of data underlies the annual estimate of Nation-wide rural traffic volumes, it is still necessary to predicate the estimates of a given year on the sequence of values obtained for previous years, with the period of the comprehensive traffic surveys taken as the base. In other words, the volume of rural traffic data produced each year is not sufficient to provide independent estimates for that year taken alone. As the base period becomes more and more remote the hazards of this procedure increase. With respect to urban traffic no comparable series of data exists; and Nation-wide estimates of urban travel can be obtained only by the device of estimating total travel with the aid of motor-fuel consumption data, and deducting therefrom the estimated values of rural travel. Increasing recognition of the necessity to know about the characteristics of urban travel gives promise that a body of data on urban traffic, comparable to that now available in the field of rural traffic, will gradually be developed.

It is unlikely, however, that at any time in the near future, continuous records of traffic volumes will be adequate for the making of independent estimates of total vehicle-miles—independent, that is, of the past sequence of such estimates and of such supporting data as the record of motor-fuel consumption. Vehicle-mile estimates are essentially a by-product that would not of itself justify large expenditures in highway research. Studies of traffic volume and composition, origins and destinations, and the patterns of highway travel have as their immediate objectives the solution of problems of highway location, geometric design, and traffic control. More broadly, they are concerned with the adaptation of the highway plant to the travel habits and needs of motor-vehicle users and the public generally; and the coordination of highway planning with land-use and other general planning. Finally, the data collected in this field should be adapted to the requirements of financial planning and the solution of highway tax problems. Estimates such as those described in this report are useful only as they further these main objectives, which do not necessarily require the maintenance of a continuous annual record of large dimensions.

Since it remains necessary to calculate annual estimates of travel volumes in terms of year-to-year changes, referred to a base period of comprehensive studies, it becomes imperative to consider whether a new base period should not be established. We cannot continue much longer to predicate an analysis of postwar patterns of highway use on estimated deviations from patterns found to exist circa 1936. A new deal in comprehensive planning-survey studies is called for.

In the field of rural travel, definite progress is being made in the direction of comprehensive coverage. About 14 States have programs in operation or in the planning stage, which will realize or approximate the scope of the earlier State-wide studies, and thus establish a new base period for rural traffic estimates. In general, these programs call for coverage of the entire rural system over a short period of years, rather than for a single 1-year survey. No such progress with respect to studies of urban travel, or the use of interview or questionnaire techniques to determine the distribution of all travel, can be reported.

There can be no doubt of the general utility, in the solution of current highway problems, of a new supply of "strictly fresh" data on the characteristics of motor-vehicle travel. In the very important studies of highway needs, both engineering and fiscal, that have been made in numerous States during the past few years, the investigators have been forced to rely on an inadequate body of information. A new set of comprehensive surveys would reinforce and give authority to the findings of these studies (although probably necessitating some modifications); and would provide a much better foundation for similar studies in States where they have not yet been made.

Obviously the new studies of highway travel patterns should not follow blindly in the path of the old. Much has been learned about highway research techniques since the days of the early planning surveys. Methods of traffic counting, classification, and truck weighing have become highly developed; and there is continuous study of the efficiency of sampling in this field. The early motor-vehicle-allocation and road-use surveys taught us much about how and how not to sample motor-vehicle travel habits. More recent developments in road-interview and home-interview origin-destination studies have forged new weapons of attack on basic highway problems. The intention here is not to offer a procedure for making comprehensive State-wide studies; but only to point out that the tools of data collection and analysis are ready to our hands. What is needed is careful, intelligent planning, with a shrewd eye on efficiency and economy in sampling, and a sober determination to concentrate on essential facts.

The necessity for using motor-vehicle registration and motor-fuel consumption data in making estimates of highway travel will continue. These data are matters of State record. Although the records themselves can be improved, and efforts are being made in that direction, it is in their utilization that the weakness lies. In order to convert motor-fuel consumption figures into classified estimates of motor-vehicle travel it is necessary to use data on average miles per gallon developed in the early planning-survey studies, with only such corrections as can be devised to account for known changes, such as the increased operating loads of trucks and combinations. In planning comprehensive State-wide studies of motor-vehicle use and travel characteristics, provision should be made for obtaining accurate statistical averages of the rates of fuel consumption in vehicles of different types and loadings.

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STATUS OF FEDERAL-AID HIGHWAY PROGRAM

AS OF DECEMBER 31, 1948

(Thousand Dollars)

STATE	UNPROGRAMMED BALANCES	ACTIVE PROGRAM											
		PROGRAMMED ONLY			PLANS APPROVED, CONSTRUCTION NOT STARTED			CONSTRUCTION UNDER WAY			TOTAL		
		Total Cost	Federal Funds	Miles	Total Cost	Federal Funds	Miles	Total Cost	Federal Funds	Miles	Total Cost	Federal Funds	Miles
Alabama	$14,819	$11,365	$5,686	226.8	$3,329	$1,663	91.8	$9,814	$5,364	202.7	$24,508	$12,713	521.3
Arizona	3,272	4,771	3,387	53.4	466	315	1.3	6,955	4,532	51.7	12,192	8,234	106.4
Arkansas	7,217	10,339	5,437	310.2	8,074	3,716	78.9	7,460	3,988	121.0	25,873	13,141	510.1
California	12,647	28,542	10,270	183.9	3,286	1,749	36.5	52,644	26,765	253.6	84,472	38,784	474.0
Colorado	8,668	4,123	2,511	53.4	3,989	2,286	50.8	6,841	4,120	78.4	14,953	8,917	182.6
Connecticut	4,302	7,238	3,502	11.1	4,424	2,526	11.0	7,101	3,264	8.9	18,763	9,292	31.0
Delaware	3,337	1,914	957	21.3	1,353	911	14.7	4,090	2,344	48.2	7,357	4,212	84.2
Florida	8,868	13,058	6,752	388.0	3,623	1,752	60.4	7,650	3,001	144.1	24,331	11,505	592.5
Georgia	8,427	11,971	6,273	307.6	17,134	7,507	97.8	34,521	17,621	846.2	63,626	31,401	1,251.6
Idaho	5,951	7,610	4,708	387.2	1,664	1,071	18.7	3,094	1,990	78.3	12,368	7,769	484.2
Illinois	25,662	47,050	23,798	516.2	20,398	10,123	203.4	41,173	20,346	515.4	108,621	54,267	1,235.0
Indiana	9,896	23,729	11,884	102.9	8,848	4,438	73.1	20,537	10,900	112.7	53,114	27,222	288.7
Iowa	9,722	16,594	7,534	663.7	6,664	3,116	247.9	16,432	7,775	694.6	39,690	18,425	1,606.2
Kansas	8,722	14,171	6,964	1,525.9	6,737	3,193	646.7	22,385	11,560	981.5	43,293	21,717	3,154.1
Kentucky	5,930	17,656	8,880	284.6	4,175	2,074	34.8	10,062	5,020	106.2	31,893	15,974	425.6
Louisiana	12,023	18,080	8,754	264.6	6,783	2,985	57.6	13,739	7,053	106.9	38,602	18,792	429.1
Maine	5,757	3,903	2,167	40.3	1,593	782	18.6	5,239	2,672	42.7	10,735	5,621	101.6
Maryland	4,016	7,494	3,522	36.9	7,770	3,756	22.7	10,793	5,469	59.7	26,057	12,747	119.3
Massachusetts	21,654	10,785	6,214	29.0	1,557	1,122	.4	18,812	9,583	29.5	31,154	16,919	58.9
Michigan	10,472	24,181	11,780	412.3	9,685	4,828	149.4	31,839	13,476	181.8	65,705	30,084	743.5
Minnesota	9,819	13,518	6,762	512.4	4,432	2,238	69.4	15,363	7,732	274.4	33,313	16,732	856.2
Mississippi	9,215	5,850	3,056	220.2	3,947	1,857	119.7	14,829	7,320	348.9	24,626	12,233	688.8
Missouri	15,943	29,249	13,807	745.4	11,166	5,785	193.3	18,339	10,238	438.9	58,754	29,830	1,377.6
Montana	10,321	11,372	7,064	451.4	3,964	2,317	93.6	8,640	5,163	236.9	23,976	14,544	781.9
Nebraska	6,182	18,738	9,960	643.8	5,407	2,924	94.8	8,553	4,300	330.5	32,698	17,184	1,069.1
Nevada	5,279	2,612	2,129	100.1	1,597	1,102	15.4	2,637	2,148	65.6	6,846	5,379	181.1
New Hampshire	3,114	3,063	1,500	23.0	1,421	955	6.6	2,990	1,528	16.4	7,474	3,983	46.0
New Jersey	916	14,373	7,035	39.5	10,973	5,412	11.9	26,099	12,966	36.0	51,445	25,413	87.4
New Mexico	6,700	5,355	3,418	220.7	2,605	1,695	77.9	4,156	2,653	77.6	12,116	7,766	376.2
New York	59,834	31,856	18,153	259.1	41,567	20,235	109.1	58,863	27,690	269.8	132,286	66,078	638.0
North Carolina	12,784	11,238	5,590	250.9	4,516	2,027	79.1	23,328	11,296	539.7	39,082	18,913	869.7
North Dakota	8,229	7,572	4,252	875.5	3,863	1,966	240.4	5,413	2,856	393.2	16,848	9,074	1,509.1
Ohio	21,403	33,641	15,932	257.6	24,119	11,859	147.1	35,094	17,972	95.3	92,854	45,763	500.0
Oklahoma	10,604	20,524	11,095	948.5	7,567	3,776	402.7	8,678	4,257	347.6	36,769	19,128	1,698.8
Oregon	6,376	4,373	2,381	45.8	3,321	1,651	26.1	6,830	3,278	114.3	14,524	7,310	186.2
Pennsylvania	23,898	20,672	10,720	19.2	10,501	5,084	29.7	60,648	30,334	165.1	91,821	46,138	214.0
Rhode Island	5,520	1,052	635	10.2	4,090	2,045	5.2	3,693	1,813	11.2	8,835	4,493	26.6
South Carolina	6,560	5,345	2,655	115.4	1,719	939	20.2	10,867	5,473	230.7	17,931	9,067	366.3
South Dakota	5,859	9,425	5,758	972.4	2,866	1,962	254.5	6,728	3,903	402.6	19,019	11,623	1,629.5
Tennessee	5,804	11,338	5,562	246.5	14,884	6,948	154.1	18,579	9,657	261.2	44,801	22,167	661.8
Texas	15,114	14,666	8,241	327.9	23,145	12,358	358.7	44,202	22,928	1,026.4	82,013	43,527	1,713.0
Utah	5,227	2,507	1,874	118.9	798	586	13.1	4,763	3,468	114.3	8,068	5,928	246.3
Vermont	2,064	2,899	1,450	43.5	1,033	515	11.4	3,018	1,500	50.1	6,950	3,465	105.0
Virginia	14,679	10,349	5,246	205.9	5,711	2,818	110.5	10,369	4,767	122.7	26,429	12,831	439.1
Washington	7,546	11,796	4,623	134.3	1,768	846	36.5	9,858	4,931	64.4	23,422	10,400	235.2
West Virginia	5,486	9,815	4,783	171.4	4,163	2,079	57.8	6,914	3,416	86.8	20,892	10,278	316.0
Wisconsin	13,821	22,310	10,963	383.2	2,836	1,346	39.1	22,822	10,341	334.5	47,968	22,650	756.8
Wyoming	4,293	1,122	729	23.5	1,990	1,294	41.1	5,009	3,232	157.6	8,121	5,255	222.2
Hawaii	2,564	5,831	2,922	33.5	3,817	1,716	11.3	3,312	1,750	15.5	12,960	6,388	60.3
District of Columbia	399	4,137	2,281	2.2	411	178	.2	14,058	6,788	2.3	18,606	9,247	4.7
Puerto Rico	3,292	11,088	5,052	57.8	1,876	639	3.9	7,917	2,915	45.9	20,881	8,606	107.6
TOTAL	500,207	642,260	326,608	14,279.0	333,625	167,065	4,750.9	803,750	405,456	11,340.5	1,779,635	899,129	30,370.4

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